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Harvesting ordinary tobacco in Kentucky

TOBACCO—A UNIVERSAL NECESSITY [See page 408]

The Physical Constitution of the Sun*

Its Evolution and Our Own

By Alex. Véronnet, Astronomer at the Observatory of Paris

Astronomers early observed the movements of the stars and in the 16th Century Kepler formulated these observations in the empirical laws which bear his name. In the 17th Century Newton's admirable law of gravitation enabled us to place these movements in equation, to explain them in all their details, to foresee and predict the future, and even to form an idea of the past by attempts at cosmogony.

In the 19th Century spectroscopy enabled astronomers to study not only the movements of the stars considered as geometric points progressing through space, but also and particularly their properties, which interest us far more. We have learned that the stars are composed of the same elements which we find upon the earth, that the sun has a temperature of about 6,000° C., *i. e.*, double that of the electric furnace, which is itself capable of vaporizing all our metals, etc. In order to relate these various observations to each other, to coördinate and explain them, and to subject them to calculation, it was necessary to explain the physical laws concerning high pressures and high temperatures. These laws we are now beginning to know.

The experiments of Andrews have established the existence of a limited temperature beyond which no body can exist in the liquid state. After that temperature is reached it becomes gaseous, and follows the laws of gases whatever may be the pressure to which it is subjected. On the other hand the experiments of Amagat have in the same manner established the existence of limited volume and limited density towards which gases tend under increasing pressure, at the same time becoming approximate to liquids in their properties. Finally, experiments of very high pressures exerted upon solids have shown that these melt and "flow" like liquids, at the same time acquiring a similar elasticity at equally high degrees of pressure and of temperature such as are met with in the stars; there is, therefore, only a single physical state, the *fluid state*, very like the liquid state, but possessing at once the rigidity of solids and the power of expansion of gases.

This special state, which is distinctly different from those commonly called solid, liquid and gaseous, is nevertheless as perfectly defined as the latter. It is governed by what is called the *Formula of Real Gases*, the old law of Mariotte (the law of perfect gases), into which has been introduced the limited density of the gas.

Let us add that according to the *Law of Radiation* or law of Stefan, a body radiates a quantity of heat proportional to the fourth power of its absolute temperature. If we double its temperature it radiates and loses sixteen times as much heat: $2^4=16$.

These two laws of real gases and of radiation based both upon experiments and upon the calculation of thermodynamics are the two chief laws which enable us to undertake the mathematical study of the constitution and evolution of the stars. They play the same rôle in physical astronomy as does the Law of Newton in mathematical astronomy. They enable us to explain the ensemble of present phenomena, to probe somewhat into the past, and even to foresee the future.

I. Previous Investigations Made Possible by the Formula of Perfect Gases.*

J. H. Lane, in 1870, was the first to undertake solving the problem of the equalibrium of a gaseous mass such as the sun by applying to it Mariotte's Law[1] of Perfect Gases. He was followed along this path by Sir W. Thomson (1887)[2], Emden (1902)[3], J. J. See (1903)[4], and finally Eddington (1917)[5]. H. Poincaré in his Lessons upon the *"Hypothesis of Cosmogony,"* in 1911 attacks the problem in the same manner. The simplicity of the formula seems to have seduced the mathematicians, who appear not to have sought to find another method in spite of the complexity of the results, which are as far, moreover, from the reality as the point of departure itself.

Furthermore, in order to obtain a complete solution of this problem it is necessary to form a hypothesis regarding the distribution of the temperatures in the interior of the gaseous mass. The simplest hypothesis consists in regarding this temperature as uniform, the same in the interior as upon the surface, isothermic equilibrium; but in that case we should obtain a density which tended towards infinity in the center, but which did not tend towards zero upon the surface. It would increase slowly towards the exterior, too rapidly towards the interior.

The hypothesis of adiabatic equilibrium was then introduced. It consisted in the belief that the distribution of temperatures was such that if a portion of a mass was displaced it assumed at each instant the temperature of the place where it found itself, and this automatically by the mere operation of its expansion or its contraction. The interior circulation accordingly would take place with neither gain nor loss of heat. The classical example of the adiabatic phenomenon is that of the transmission of sound in the air. The vibrations are so rapid that the corresponding variations of temperature have not time to occasion a loss of heat. But there is nothing to prove that within the sun all these phenomena of displacement are subject to the same conditions of rapidity.

The theory of adiabatic equilibrium has been advanced furthermore because it is not destroyed by the movement of convection of the mass, but it is precisely this which, if it exists, renders impossible any movement of convection. Since each particle has a density and a temperature determined by its very position, it has the same density as the surrounding particles and remains at rest. In order for it to have movement it is necessary that both its density and its temperature should be different; but there would then be an exchange of heat, and the rupture of the adiabatic equilibrium, and the idea of superficial radiation cannot be entertained, except at the price of this supposition.

In any case the calculations based upon this hypothesis give a temperature of several million degrees Centigrade at the center of the sun, which seems rather formidable; but what is still more serious from a practical point of view, they do not enable us to determine the conditions of temperature and pressure at the surface which, however, interest us far more from an astronomical point of view than a hypothetical central temperature. Thus, in order to preserve the adiabatic equilibrium the temperature would have to increase in the solar atmosphere by 14,000° C. in 720 kilometers, while the temperature at the surface is only 6,000° C.

The formula of perfect gases applied to the evolution of the sun and the stars has given no better an explanation of these than of their physical constitution. It is demonstrated that the temperature of such a gaseous mass which contracts and dilates varies in inverse ratio to its radius; we would then have extremely rapid cooling of the sun, which must be supposed to have radiated less in the past than at the present time, which runs contrary to both modern and ancient geologic observation.

To sum up, the formula of perfect gases does not enable us to explain either the physical equilibrium of the sun and the stars at the present time, nor their past or present evolution. It can only be applied to masses which are very slight or very much diluted such as nebulæ, comets, atmospheres of stars and of planets.

II. Equilibrium of a Gaseous Mass and Physical Constitution of the Sun.

We know that the sun has a temperature of about 6,000° C., probably increasing in the interior. This is double the temperature required for the fusion of the tungsten which forms the filament in our electric lamps; hence the elements which constitute it must have a temperature above that of their critical point, and must behave like real gases except at the surface where the intense radiation permits a shining condensation similar to our fogs and clouds; this is called a photosphere.

Let us apply to this mass the formula of real gases with limited density. We can easily find the law of the variation of density at each point as a function of the distance from the center. It depends upon the temperature at this point as well as upon the pressure of all the superior strata attracted by all the interior strata. We cannot attempt to define it practically except by making use of simplifying hypotheses, which it is necessary to verify. It may be supposed that for a certain thickness the temperature and the weight remain almost constant.

We find then that upon the stratum where the density amounts to a third of the limited density, this density increases very rapidly and forms an actual threshold, a very definite demarkation between the strata situated above it, which constitute the atmosphere, and the strata situated below it, which constitute the nucleus.

Numerical calculations prove that in the case of the sun the increase is of such rapidity that the density will there attain almost its limited value in a few kilometers only. The thickness of the transition stratum is therefore very slight. We may consider the temperature and the weight as being practically constant at that point. The hypotheses stated above are found to be completely verified and the result remains certain whatever the law of the temperatures and of the densities in the interior may be.

The delimitation of the atmosphere and of the nucleus would be on the whole as marked upon a completely gaseous star, such as the sun, as upon the earth itself, if we regard the thickness of the seas as the zone of transition between the atmosphere and the nucleus. The radius of our gaseous mass would therefore be quite as perfectly defined, both theoretically and practically. Moreover, since the mass is gaseous there is an intimate mixture of all these elements as there is of the nitrogen and the oxygen in the air. There are no strata of different density—the interior mass is homogeneous. The law of densities stated above enables us to calculate therefore that the average density of the sun is equal to about 0.01, to the average limited density of the elements which compose it. We can, therefore, attempt to frame an idea of the nature of these elements.

The average density of the sun is 1.41. The limited densities of hydrogen and of oxygen at the ordinary temperature are 0.09 and 1.43. The liquid densities are nearly the same. The average molecular weight of the elements which compose the sun must therefore be greater than that of oxygen. But the sun has a minimum average temperature of 6,000° C. In order to render these data comparable, therefore, it is necessary to determine, as nearly as possible, what would be the density of the sun at zero and the limited density of gases at 6,000° C., and to bring the results into concordance.

The sun and the planets were probably formed in the same medium from the same elements, with a tendency of the heavier elements to group themselves at the center. The regular increase in density of the planets the closer they are to the sun would lead us to ascribe to the latter a density of ten to twelve instead of 1.41. Its present temperature would give it, therefore, a volume eight times as great, and a radius double that which it was at zero degrees Centigrade. Moreover, the increase of the coefficient of expansion of solids and of liquids, the variation of the limited volume of gases with the temperature (Amagat) lead us to believe that there is an expansion of precisely the same kind for temperatures from 6,000 to 10,000° C. We are thus led to believe that the elements which compose the sun have an average atomic weight in the neighborhood of 110, which is equal to that of silver.

The same calculations show that the average interior temperature of the sun cannot be more than double the temperatures indicated above, for its density at zero would be too great in relation to that of the planets; and, furthermore, the average atomic weight would be 220. It would be necessary, therefore, to believe that the sun is entirely composed of heavy atoms, which are rather exceptional.

It may be added that the formula of densities permits us to calculate the increase of temperature which would produce an inversion of densities, and intimate mingling of the whole mass, and finally an equalization of temperatures. This maximum increase would give about 30,000° C. at the center. Finally, it is possible to calculate the temperature of formation of a star by the condensation of the elements in a homogeneous medium. We obtain a maximum of 10,000° C. for a star like the sun. This is far from the millions of degrees given by the law of perfect gases, and these numbers appear far more rational to us. They permit an extrapolation of our physical laws less hypothetical, likewise, and consequently giving more value to these calculations.

We have seen that a sudden increase of density forming a separation between the nucleus and the at-

*Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Revue Generale des Sciences.*

[1]Am. Jour., 2nd series, vol. L, p. 57.

[2]Phil. Mal., 5th series, vol. XXIII, p. 287.

[3]Ann. d. Phys., vol. VII, Part 1, 4th series, p. 176.

[4]Astr. Nach., No. 4053, vol. CI-XIX, p. 321.

[5]Monthly Notices, Dec., 1917.

mosphere takes place when the density amounts to one-third of the limited density. By taking into account the variation of this limited density with the temperature we can easily determine the corresponding pressure. We find that it is included between narower limits whatever the temperature and the law of dilatation may be. It may vary from 1,000 to 2,000 atmospheres, with a probable value of approximately 1,500 atmospheres for the sun. This enables us to determine very completely the extent and the physical conditions of the solar *atmosphere*. This pressure corresponds in fact to a weight of fifty kilograms per square centimeter upon the sun; thus the atmosphere forms one five hundred thousandth part of the total mass. By way of comparison it may be observed that the terrestrial atmosphere forms only one millionth part of the mass, with only one kilogram per square centimeter.

If we now calculate the quantity of hydrogen contained in the water of the seas alone, and assume the same proportion upon the sun, we find that there must be a mass of 1,200 kilograms per square centimeter. This is at least twenty times as great as the amount necessary to produce the critical pressure in order for all the elements to attain the third of their limited density and which forms the inferior limit of the atmosphere. We may say, therefore, that the entire atmosphere of the sun is composed almost solely of hydrogen, within which are diffused the vapors of the metals of the nucleus, these being partially condensed in their lower portion just as the vapor of the water of the ocean is diffused in the lower portion of our atmosphere, and is there condensed into fogs or clouds.

Observation shows that the absorption of light by the visible solar atmosphere is almost the same as in our own atmosphere. The mass traversed must therefore be nearly the same. The pressure at the surface of the photosphere (visible surface) must therefore be about thirty atmospheres, since the weight there is twenty-eight times as great as at the surface of the earth. Furthermore, spectroscopic observations show that the solar stratum where the pressure is one atmosphere is found in the reverting stratum. Numerical calculations proove that the thickness of the two layers in question is 620 kilometers, or about 1″, which is precisely the thickness of the reverting stratum.

The distance from the surface of the photosphere to that of the nucleus would be at the maximum 800 kilometers. This would be the thicknes of the stratum of shining clouds and fogs resting upon the denser nucleus and remaining gaseous. This thickness must be divided by the molecular weight of the elements which compose it, which would reduce it perhaps to a few tenths of a kilometer. The spots would be rents in this stratum of clouds reaching down to the nucleus.

Calculation shows likewise that the atmosphere of hydrogen must be limited to a depth of about 10″, which is that of the chromosphere. A still lighter gas, such as the coronium of the Corona must be, may extend still further.

The same calculations and the same conclusions apply equally to all masses greater than that of the sun, as well as to masses only one millionth as great. The thickness of the atmosphere and its comparative value with relation to the total mass vary solely to this mass. A star which is greater, and therefore hotter than the sun, would therefore have an atmosphere less thick, from which the reverting stratum would have more or less disappeared. It would, therefore, have all the characteristics of a white star. A smaller star, on the contrary, would be less hot and would have a more absolvent atmosphere, and this would probably result in a red star.

To sum up, the sun must be formed of a nucleus and an atmosphere separated by a very rapid variation of density. The nucleus is formed by the intimate and homogeneous mixture in the gaseous state of elements whose average atomic weight is approximately that of silver at a temperature increasing from 6,000 to about 10,000° C. The atmosphere is formed almost solely of hydrogen disassociated by the high temperature. The vapors of the nucleus, diffused in the atmosphere and condensed by radiation and cooling to the state of fogs, form a shining and visible surface, which we see as an aviator or a mountain climber sees the sea of clouds he looks down upon, and whose variations of aspect he can study.

III. RADIATION AND EVOLUTION OF THE SUN.

The sun radiates an enormous quantity of heat, two and one-half calories per gram per year, yet it is not perceptibly cooled. The temperature of the earth depends directly upon that of the sun, and the former has not been appreciably lowered during the last two thousand years. The Olive tree grew in Provence in the time of the Romans, and a difference of only a few degrees would have rendered its development impossible, hence, there must be something which preserves the heat of the sun. Helmholtz found the explanation for this in the contraction of the sun. It has been demonstrated that all other causes such as combustion, chemical reactions, radium, the fall of meteorites, etc., could furnish only a merely negligible difference[6]. We know that every compression or contraction requires an expenditure of energy and produces heat. Thus the pump of the bicyclist who inflates his tire becomes heated. Upon the sun the pressures, and consequently the work of compression, are so great that the total contraction corresponding to a cooling of one degree disengages one thousand times as much heat as the cooling pure and simple. Its cooling instead of requiring several thousand years would require several millions. It is very simple.

Furthermore, we can easily calculate the quantity of heat of energy which the condensation or the compression of the elements of the sun has been able to produce since the beginning. This quantity depends comparatively little upon the initial conditions of the nebulæ and of the internal state of the sun. Lord Kelvin estimates the probable number to be fifteen million times the quantity of heat which it expends annually, and in any case to be certainly comprised between ten and twenty million times[7]. If the sun had always radiated in the same manner, in the same conditions, we could not estimate the time of its origin, and, consequently, that of movement and life upon the earth at more than fifteen million years. But let us suppose merely that there was in the past a double temperature: in that case its average radiation would have been sixteen times as great, and all this heat would have been dissipated only in a million years. We see by this to what a degree the evolution of the sun, and of our own earth depends upon the physical conditions of the star, the present physical conditions extended both into the past and into the future.

But the theory of Helmholtz supposes that the sun contracts while cooling, as a normal liquid does. However, the sun is certainly gaseous, and according to the formula of perfect gases it should dilate while cooling, as we have seen. If we take the formula of real gases we can demonstrate, on the contrary, that there will be contraction as soon as the density reaches the quarter of the limiting density of the gas. The mass of the sun, whose nucleus has a density of more than one-third the limit, will, therefore, be caused to contract by the cooling and the theory of Helmholtz becomes integrally applicable to it. Herein we have acquired a fact of extreme importance which is absolutely indisputable, and which enables us to deduce other consequences which are still more important with reference to the past and the future of the sun and the earth.

The sun cools and contracts. Hence it was formerly both larger and hotter and cooled still faster. It may be demonstrated from this fact that the speed of contraction was proportional to the fourth power of the temperature, according to the law of Stefan, and to the fourth power of the radius. We are able therefore to relate the radius to the temperature by the formula of expansion, and completely solve the problem. In every case we note that the contraction is very rapid in the beginning and in the past, and becomes slower and slower with the pasage of time. We find, as an average value, that the time which has elapsed since the origin, expressed in millions of years, is in inverse ratio to the fifteenth power of the radius.

If we consider the cubic expansion as constant (which is the case in gases) we find that this time varies practically from 820,000 to 940,000 years, with a probable value of 910,000 years. The temperature for a radius equal to 1.2 would be 11,000° C., that is, less than double the actual temperature, and the anterior time of contraction would be negligible, being only 30,000 years.

Even if we consider the linear expansion as constant, *i. e.*, the expansion in volume as proportional to the cube of the temperature, which may be regarded as a limit, we find a million and a half years as the total time of contraction. With a radius equal to 1,2 the temperature was 8,400° C., the time was 1,200,000 years, and the time previously elapsed did not exceed 200,000 years.

These calculations are based upon the hypothesis that the cooling extends to the whole mass by reason of the complete mingling of the elements, which seems to be pretty near the actual state of affairs. If we assume a superficial cooling, the time of evolution will be still more diminished.

It may be affirmed, therefore, that our sun, in the form of a star, and giving forth radiations, has not been shining more than about a million years. Through the same reasoning its radius cannot have exceeded its present radius by more than two or three-tenths, and its maximum temperature has remained less than twice the present temperature.

It may be said, therefore—and this is absolutely remarkable—that the physical conditions of the sun have never been very different from those known to us at present. It can easily be shown, therefore, that the conditions of its radiation, of its cooling, and of its contraction have been almost the same.

The calculations given above are strictly applicable, therefore, and are not merely theoretic, but constitute a first foothold on solid ground which will enable us to advance to ulterior conclusions.

Furthermore, as the stars are very far apart, causes of disturbance are reduced to the minimum, thus enabling us to prolong the study of their physical conditions as well as of their movements into an extended period of time.

The same calculations enable us to foresee to some extent the future of the sun. In 160,000 years its radius will contract by one hundredth part and its temperature will be lowered by 2,000° C. In four million years this radius will be diminished by one-tenth, and the temperature will have fallen to 4,200° C. Possibly it will be below the critical temperature of the greater number of its elements. The mass will pass from the gaseous into the liquid state. The mechanism of the intimate mingling of the elements and of the regeneration of the heat through contraction will be suspended. The temperature at the surface will rapidly diminish and the sun will become extinct. In any case this extinction will certainly be complete in ten million years, the radius being reduced to 0.86 and the temperature to 3,500° C.

The same formulas enable us to study the phases of the evolution of any other star whatever in function of its mass, and to determine the conditions which have caused its development to be more or less advanced than that of our sun.

Calculation, extended to the ***diffused stars***, of low density and very high temperature, shows that they must have originated from a sudden condensation or from a shock (new stars), and that their intense radiation cannot be maintained regularly by simple contraction (variable stars). But they are all in the phase of cooling. There can be no phase of heating, with increasing temperature, for a gaseous star in physical equilibrium. There can be no increasing temperature except by the *free* fall of the elements towards the center under the influence of attraction.

Finally a gaseous mass may remain in the state of a stable nebula with a great radius and a very low temperature, maintained by the radiation of the surrounding stars formed before itself. Thus a mass equal to that of the sun, occupying a volume with a radius equal to from fifty to one hundred thousand times the distance from the sun to the earth, would remain in equilibrium at the temperature of 7° C. absolute, which is that which would be possessed by the space occupied by the solar system if the sun did not exist[8].

IV. TEMPERATURE AND EVOLUTION OF THE EARTH AND OF THE PLANETS.

The law of radiation permits us to calculate the temperature of a body in function of that of another which heats it, as does the sun. The temperature of the earth, for example, is such that the heat which it radiates into space is equal to that which it receives from the sun. It would be quite difficult to take into account the influence of the atmosphere, but taking as our point of departure a temperature of 6,000° C. for the sun, we obtain a temperature of 34° C. (93.2° F.) at the equator, which is precisely the maximum continental temperature. Upon the parallels of latitude the temperature is proportional to the square root of the cosinus of the latitude[9].

For Paris we obtain a temperature of 8.5° C. (47.3° F.), while the average for the last 50 years is 10.1° C. (50.18° F.) In practice, therefore, we may regard as sufficiently exact this determination of temperatures in function of that of the sun, assuming an almost en-

(*Continued on page 411*)

[6]C. R. Acad. d. Sc. (Paris), March, 1914, vol. CLVIII.

[7]H. Poincaré: Lessons upon Cosmogonic Hypotheses, p. 200 and 202. He obtains 32 million years as a maximum, but by adopting the ancient solar constant of Povillet, which he himself declares to be too slight (p. 191).

[8]For the demonstrations of the development see the *Bulletin Astronomique* for May-June, 1918; the *Bulletin de la Société Astronomique de France* for June, 1918; the *Comptes Rendus*, vol. CLXV, p. 1035; vol. CLXVI, pp. 100, 286, 642, 812, 901.

[9]Modern Cosmogonic Hypotheses, p. 61. Pub. by Hermann.

Anomalies in the Animal World—Part XIV

Some Deep Ocean Types and Families of Fishes

By Dr. R. W. Shufeldt

PASSING the Sharks, Rays, and Ganoids, we find many queer fishes in divers other families and groups that our limited space will not allow of describing here. There are in mind, however, the Mola or short sun-fish; the electric eels; the *Chaetodons*, which can shoot flies with drops of water ejected by its squirt-like snout; the Pilot fish, which follows vessels in their course; the Bat Maltheais and no end of others, some of which will be taken up in the next chapter.

As set forth previously, there is no assemblage of vertebrates, existing and extinct, which presents a greater number of curious and anomalous species than that of fishes. The array is almost endless, and yet there are still many, many forms existing which, at the present time, are totally unknown to science. Especially is this true of the deep oceanic types and families.

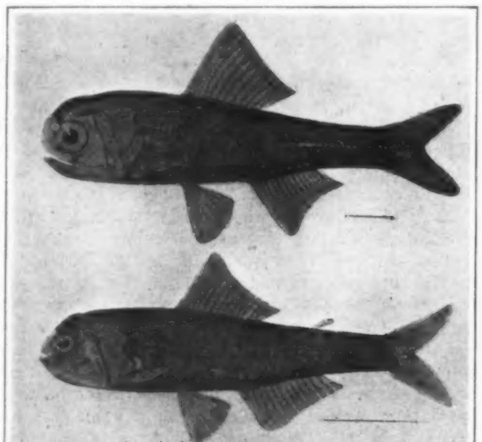
Turning to these latter for the next material to illustrate fish anomalies, there is to be noted the unique "Torch-fish (*Linophryne lucifer*), from the nose of which "there stands erect upon a stem a small organ, elliptical in form and phosphorescent in function, which the fish has the power of making very luminous or the reverse, at its pleasure." The Torch-fish also has an elongated and slender filament swinging from beneath its lower jaw. Its free end is tufted. Now, small fish are attracted by this freely moving little bait, as well as by the beautiful light emitted by the "torch," and, darting after the former by the aid of the latter, they very frequently land in the capacious mouth of their allurer, who quickly devours them. The physiology of this phosphorescent organ is, as yet, not fully understood.[1]

During the last half century we have learned something of these deep-sea fishes, as a few experts in biology—and especially in ichthyology—have devoted years to their consideration and study, so that some little light has been shed upon the subject which, by the way, is probably the least known of all the departments of natural science. The specific forms of life in these truly vast bathypelagic regions of the oceans, including the various bathybial zones above them, must be, in numbers, something enormous. So far as our knowledge carries us, and as we would naturally expect, the great majority of these forms are fishes; and in a general way, as we have seen, they are spoken of as "deep-sea fishes."

Most of them have been obtained by means of various mechanical contrivances, and dredges used by naturalists and their assistants aboard exploring vessels, specially fitted out for such investigations. Specimens have thus been taken from the surface down to depths considerably over a distance that most people would decline to believe. For instance, one of the Caratiids (*Mancalia uranoscopus*) was dredged in 2,400 fathoms of water in mid-Atlantic by the naturalists aboard the "Challenger" (Goode and Bean). As there are six feet to the fathom, this fish was taken 14,400 feet from the surface, a distance of upwards of three miles!

Many of the fish never approach the shore by many miles, unless driven there by storms and other agencies. Some of them are found practically in all the oceans of the world, while the ranges of others are absolutely unknown. The deeper into the ocean their habitats extend, the more do the species differ from the surface or rather shallow water forms in appearance, character and structure.

Of the seven or eight hundred deep-sea fishes recorded, those taken at the greatest depths are among the most extraordinary animals known to science. We are almost entirely ignorant of their habits, of some of them completely so. Thousands doubtless still remain unknown to us, as the proper appliances for their capture have never been constructed. Probably some, yes, many of the larger species inhabiting the greater depths never will be seen by man, as it is so easy for them to escape from any contrivance lowered down into the ocean with the view of effecting their capture; while others are so small that they readily slip through the finer meshes of the dredge. Many specimens today are unique and may ever remain so. The skeleton of one deep-sea fish, and a pretty big fish, too, was described by me many years ago, the specimen having been secured some fifteen or more years prior to its having fallen into my hands; and yet the duplicate of this specimen has never been taken.[2]



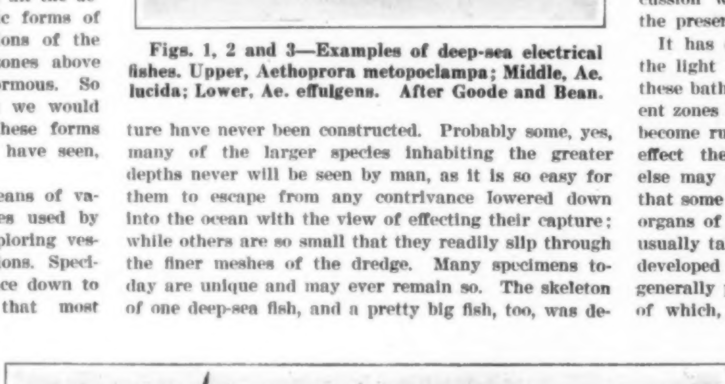
Figs. 1, 2 and 3—Examples of deep-sea electrical fishes. Upper, Aethoprora metopoclampa; Middle, Ae. lucida; Lower, Ae. effulgens. After Goode and Bean.

Often the more delicate forms go all to pieces when brought to the surface, owing to the absence of pressure and other conditions under which they have lived in their bathybial homes. As pointed out in a previous chapter, in some the eyes are so small that even expert ichthyologists have overlooked them, when searching for descriptive characters; while in other species these organs are enormous in proportion to the size of the species possessing them. Various others, as pointed out below, can swallow fish three or four times larger than themselves, and specimens have been taken with such victims in them, thus proving this fact. The torchfish described in a previous paragraph had in its stomach, when taken, a fish much bigger than itself.

Numbers of these deep-sea fishes stand among the most grotesque creatures in their appearance that one can possibly imagine, not only being most curious in contour, but often possessing the strangest kind of appendages attached to various parts of their bodies.

Deep-sea fishes are rarely brilliantly colored, many species being black, and among these albinos often occur. Others are silvery, and in some the appendages may be scarlet, but as a rule bright colors are entirely absent. By degrees we are gaining information on the matter of pressure and its influence, referred to above: on the effect of sunlight on the species when these piscine forms are first subjected to it upon being removed from the dredge; on the presence or absence of vegetation at different depths in the oceans,—for when it is absent, the fish living in such zones are perforce carnivorous types; on the effect of deep-sea temperature; on the absence of motion at varying depths; on the influence of currents, and so on. All of these questions are extremely interesting and important, but their discussion would occupy altogether too much space in the present connection.

It has already been pointed out above that, where the light fails or is diminished in varying degrees in these bathybial depths, in some of the species in different zones the eyes have not been lost as a consequence, become rudimentary or otherwise modified in order to effect the proper accommodation. Then something else may happen, and this quite apart from the fact that some of the species may possess certain tentacular organs of touch to help out the sense of sight. What usually takes place is this: the fishes referred to have developed certain phosphorescent or luminous organs, generally placed in their skins or elsewhere, by means of which, there is every reason to believe, they are enabled to see to a certain extent and to obtain their food. Such species have elsewhere been designated by me as the Phosphorescent fishes, and they stand among the most interesting of all the oceanic fauna yet known to us.



Figs. 4 and 5—The Black Swallower (Chiasmodon niger). A deep-sea fish that, in feeding, swallows other fish that are larger than itself. Upper figure, view from above; lower figure, left lateral view. In both views a fish that has been swallowed can be seen plainly through the abdominal walls. After Goode and Bean.

Of the ordinary phosphorescent fishes little need be said; in fact, numerous as the species are, we do not know so very much about them. The family *Myctophidae* includes many of them, and, as a rule, among other structures they are characterized by possessing the aforesaid luminous spots. These are found to be certain little round bodies embedded in the skin, except on the dorsal surface of the fish (Figs. 1, 2 and 3). They are round and shining and more or less numerous, having a peculiar pearly appearance, while their various distributions on the fishes of different species has been employed with effect in classification.

Formerly some naturalists believed that the larger of these organs—those having a lenticular body in their interior—were actually "accessory eyes,"—a view that cannot be sustained for an instant; though that they do emit a phosphorescent light there is not now the least doubt.

[1]Schufeldt, R. W. The "Chapters," pp. 77 and 78, Fig. 14, which latter presents a side view of this remarkable fish, and, under "Torchfish," this is reproduced in the new volume of the *Century Dictionary*. This fish was first described by the late Professor Robert Collett of Norway (P. Z. S., 1886), and my drawings are simply adaptations from those he originally published. So far as known to me, there has been but one specimen of this fish secured up to the present time. It is a small species less than two inches long. Other papers of mine give further particulars of what is known of this "Torchfish," as well as of other deep sea forms. (*Discovery*.) "Fish that show lights in Ocean Gloom." N. York, Oct., 1907, vol. 1, No. 6, pp. 119-122, illus.; also, *loc. cit.* "Formidable Powers of Electric Fishes." *ibid*, July, 1907, No. 3, pp. 49-51, illus. A good cut of the Torpedo fish is given here, and another of its electric organ.

[2]Poey. F. Anal. Soc. Esp. Nat. ii, 1873. Shufeldt, R. W. Journ. Morphology, ii, 1888, 272-296, with 13 figures. This species is known to science as *Grammicolepis brachiusculus*, Poey.

Speaking of the deep-sea fishes that swallow other fish much bigger than themselves, there is no better known example than the Black Swallower already alluded to above. This species (Figs. 4 and 5) represents the family *Chiasmodontidae*, and has been named *Chasmodon niger*. It is a most voracious fish, having distensible skin, and an even more distensible stomach. This is the only species of the family known, and we have found but five examples of it since Lowe in 1850 got the first one off Madeira in 312 fathoms of water. Twelve years later Johnson got the second example in the same locality. Number three was picked up near the island of Dominica; it was floating on the surface. On August 26, 1873, in 1,500 fathoms, the "Challenger" obtained the fourth example in mid-Atlantic, while the fifth and last was found floating on the surface at Le Have Bank (June, 1880), by Captain Thomas F. Hodgdon of the Gloucester schooner "Bessie W. Somers." This speciment was secured by the U. S. National Museum.

As its specific name suggests, this fish is entirely *black;* but its size cannot be given here as it is not known to me. Goode and Bean do not give it, and Johnson's P.Z.S. paper (1863) is not at hand.

The Black Swallower is a fish that doubtless inhabited the Atlantic Ocean at very great depths; but notwithstanding this, we shall probably secure other specimens of it in the future, more particularly when the officers of our navy are taught the value of such material, and the desirability of preserving it when found.

Other most remarkable deep-sea fishes, with enormous mouths and widely dilated pharynxes, are to be found in the families *Saccopharyngidae* and *Eurypharyngidae*, examples of which are here presented in Figs. 6 and 7.

Eurypharnyx pelecanoides or the Pelecan Lyomerid has a tiny head with an enormous jaw development, as shown in Fig. 6. The jaw bones are very narrow and slender, while the surrounding skin and the jaws themselves are marvellously dilatable,—a condition due to the development of its habits. Gill and Ryder have pointed out for us in *Science* and elsewhere that, in regard to the development of this prodigious pouch constituting the mouth and its cavity, with its minute teeth upon the jaws, it precludes "the idea of the species being true fish of prey; it is probable that they may derive their food from the water which is received into the pouch, by a process of selection of the small or minute organisms therein contained. The skin constituting the pouch, it may be added, has a peculiar velvety appearance, and also reminds one of the patagium or wing membrane of a bat."

This fish, as well as the one next to be described, has a length somewhat exceeding two feet, but then their tails are long and whiplike.

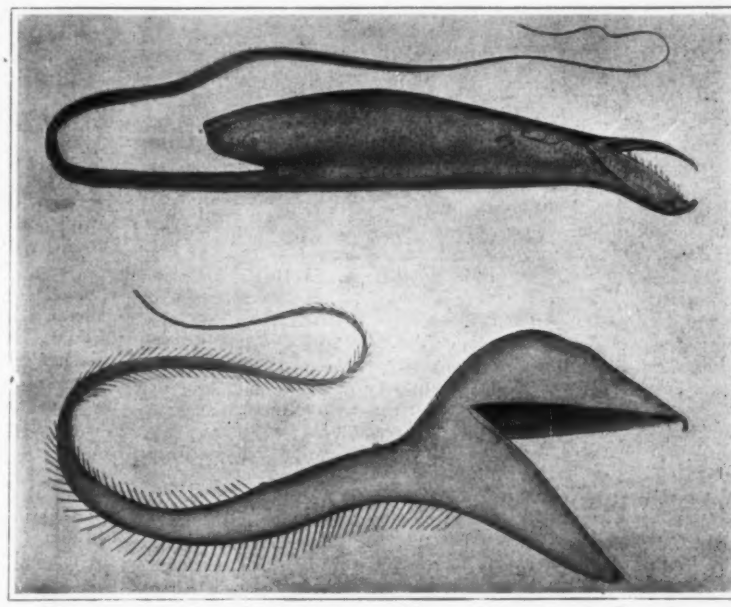
As to the *Saccopharyngidae*, Jordan and Evermann (Part I, p. 405) call them the "Gulpers," on account of the big fish they can swallow, often, as has been said, fish bigger than themselves. *S. flagellum*, now *S. ampullaceus*, is here shown in Fig. 7, and there are at least four specimens of it known. Three of these were found on the surface of the ocean, having died from swallowing fish too big for the stomach's capacity!

We know little or nothing about these *Lyomeri*, as they are called, and nothing of their *internal* structure; and the specimens are too valuable to study in this regard, although science is in possession of *four* of them.

Passing from the few—very few—deep-sea fishes noticed in this Part, out of the large array of them already described in ichthyological books, we come across some few altogether different kinds that not only are not deep-sea species, but actually fish that come ashore at different times and for various purposes. One very ordinary-looking fish of usual form is a very celebrated species, however, on account of its climbing propensities. It is found in India, and has been called the Climbing Perch (*Anabas scandens* of the family *Anabantidae*.

There is a cell-arrangement in connection with the upper pharyngeals of this fish for a reservation of water, by means of which its gills are moistened when the animal is on dry land. In going ashore, these fish leave the water for some distance behind them, and they can climb up a tree for six or seven feet or more, using their pectoral gills for the purpose. Although it is well known that an *Anabas* can live for a long time out of water, it is not known to me at this time exactly for how long. An average size specimen may be about six inches in length, and would not attract special attention from the casual observer, as such a person might easily mistake it for some sort of a bass or perch.

There are several species of this family, and not very much has been written about them,—that is, we find very few references to them in American fish literature.



Figs. 6 and 7—Remarkable deep-sea fishes. Upper figure, Eurypharynx pelecanoides; lower figure, Saccopharynx flagellum. After Goode and Bean.

Even a more extraordinary genus of fishes of this character is the genus of gobioid fishes, named *Periophthalmus*, of which *P. koelrenteri* is a good example. They receive their generic name from the fact that their eyes are near together on top of their heads, and project prominently, thus rendering them capable of "looking around" which these fish can do with exceptional facility wherever they may be.

These fish are small, and remind one of any of the ordinary species of our Darters, so frequently seen in aquaria containing native fish. But the eyes of Darters are not modified as in the case of *Periophthalmus*, in that they can raise and depress them, through which an all-round and uninterrupted vision or view can be commanded.

On the muddy mangroove flats in the Malay region, and in northern Australia, are the places where we meet with *Periophthalmus* in abundance, and where they are known to the residents as mud-skippers or mud-hoppers (Fig. 8). This appellation they fully deserve; for not only do they come out of the water onto these mud-flats, but when there they skip about as though terra firma was where they really belonged. These expeditions ashore are usually made at low water, and the fish being, in a way, gregarious, they are generally to be observed in detached groups, enjoying the sunbath on the shiny and slippery mud. Ever and anon they will, in sport, skip about after each other, and, what is more extraordinary, climb up for some little distances on the exposed and elevated roots of the mangroove trees. When up some little distance, they settle down and appear to be spectators of the antics of their companions on the smooth mud below.

Fig. 8—The Mud-hopper (Periopthalmus). A remarkable fish of North Australia and the Malay region that comes ashore for recreation. After a drawing by Saville-Kent.

Specimens of this fish have been collected by Saville-Kent, who tells us that the "capture of the little fish seems at first sight an easy task, but woe betide the reckless enthusiast who ventures on the treacherous ooze in its vain pursuit. He will emerge from the enterprize with bemired raiment and a much-chastened spirit. Should however, the acquisition of specimens be an important object, the enlisted services of the wily native, who needs but a little paint and a pearl-shell for the renewal of his full-dress apparel, will speedily secure an abundant supply."

Totally unlike all ordinary fishes, this mud-hopper of northern Australia cannot remain continually under water, as it would be drowned. Moreover, the external tissues of the animal, as its skin and so forth, seem to require the full blaze of the sun, and the action of the air ashore, to maintain their healthy, normal condition.

Periophthalmus is doubtless descended from species of fish that had no such habits as have just been described; while, in the course of time, and for reasons we probably will never know, there was occasion for it to leave the water from time to time to maintain its existence. Apparently, as time passed, it was obliged to remain ashore for increased periods, and, finally, to amuse itself in some way while there. As all this came to pass, something in its structure must furnish the means of enjoying increased atmospheric respiration, which the ancestral stock of the now-existing species did not possess.

Through evolution such a provision was forthcoming, and must have required many, many generations to produce. As now found in the fish's *tail*, it consists in a supplementary organ for respiration that the species employs in an absolutely unique and anomalous manner in nature.

When resting upon the mud for any length of time, it does so close to the water's edge, as one individual is shown doing in Fig. 8, immersing its tail, to a greater or less degree, in the water. This allows of the thin, membranous appendage it supports to exercise its function, which is, as stated above, an accessory respiratory organ, or in fact a *caudal gill*. Through this latter, when thus resting in the water, the blood circulates with increased energy, and the requisite oxygenation of the same is maintained.

Periophthalmus must not be passed by in this brief reference to its strange habits without a line or two to invite attention to the big black and scarlet crabs that are ensconced among the roots of the mangrooves, resorted to by our queer, pop-eyed little fish. One of these crabs is to be seen in Fig. 8, beneath the roots of the tree in the middle foreground; but it gives no idea whatever of the size and brilliant coloring of the great *fighting* crustacean. Indeed, its fighting propensities are so apparent when approached that they are called and known as the Mangroove Fighting Crabs. It is, however, as a term only applicable to the male of the species, which is likewise called the Calling crab, as it seems to beckon to one as it walks along with its immense, up-raised claw, in a way suggesting the beckoning of one by the hand, when so employed.

Some of the relatives of this crustacean are beautifully colored species, and they are quite as pugnacious by nature as the species just described.

The land fauna of Australia rivals that of any other in any part of the world in matters of interest, importance and singular uniqueness, and doubtless, upon comparison, her fish fauna occupies a similar place among the world's groups of the scaly denizens of the deep.

Detection of Cider in Wine

FIFTEEN c.c. of the wine is shaken with a few c.c. of concentrated sodium nitrite solution; pure wines give a bright yellow or yellowish-brown coloration, while cider or perry is colored dark brown or brownish-black and a brownish-black precipitate separates. This precipitate is insoluble in water, alcohol, ether, etc., but dissolves in alkali solution giving a red solution. Wines when treated with both sodium nitrite and potassium hydroxide give a yellow coloration, while cider and perry and mixtures of the same with wine yield a pure red coloration.—*Note in J. Soc. Chem. Ind. on an article by P. Medinger and F. Michel in Chem.-Zeit.*

Copper-Base Bearing Metals*

In the early days, copper-tin alloys were almost universally used, the idea then being prevalent, and is still held by many, that a bearing to resist wear must be hard and the harder the better. The favorite bronze bearing contained 90 per cent. copper and ten per cent. tin; frequently in service which was considered severe, even higher proportions of tin were used. Such hard alloys have great resistance to compression, but as a rule they had a very wide factor of safety in this respect. Such bearings, because of their inability to adjust their surfaces to slight irregularities in the journal, or to foreign bodies, immediately begin to cut, and heating results. With a slight rise in temperature, the film of lubricant becomes thinner, and further cutting follows, if not actual gripment of the bearing with the journal.

Many years ago Dick, of England, appreciating the advantage to be derived from a slight plasticity in a bearing, added some lead to the then standard bearing metal, not substituting lead for tin but reducing the copper, and produced the alloy, which has long held favor as a bearing metal, copper 80, tin 10, lead 10 per cent. Dick's alloy also contained some phosphorus, but the main point is that this was the first step toward the production of bronze alloys having a plastic nature. Lead does not unite to form an alloy with copper, but remains mechanically mixed, so that structure of the alloy is that of a hard matrix with the soft metal imbedded therein.

It was not until several years later that tests were conducted on the Pennsylvania Railroad, under the direction of Dr. C. B. Dudley, who investigated the copper-tin-lead series within certain limits of the 80-10-10 alloy; he studied, not only the alloys containing lead above 10 per cent. in which copper was replaced by lead, but also in which tin was replaced by lead. His conclusions, which have since become firmly established, are: (1) The rate of wear diminishes with increase of lead in the alloy. (2) The rate of wear diminishes with decrease of tin in the alloy. Fortunately, the alloy containing least tin and highest lead exhibits least tendency in service to give trouble from heating.

Notwithstanding the decided merit of copper-tin bearings containing lead, prejudice was strongly against them, simply because lead is a low-priced metal. It was even intimated that such alloys were frauds, should be considered such, and dealt with accordingly.

I have mentioned Dr. Dudley's discoveries because it was due to its findings that the Ajax Metal Co. instigated research work, now 20 years ago, which has led to the production of alloys still higher in lead and lower in tin than those which he was able to produce. He experienced foundry difficulties which apparently limited his maximum lead alloy to 77 copper, 8 tin, and 15 lead. This was called Experiment B alloy, and has since been widely known as "Ex. B metal."

Having found due regard to the raw materials used, and by following good foundry practice, we have been able to produce alloys carrying 5 per cent. of tin and as much as 30 per cent. of lead which would show no segregation of lead, even if cast into large bearings. By this I mean that such bearings will show no indication of metallic lead upon any surfaces. Lead being only mechanically held in the alloy, it is prevented from segregating by the quick setting of the matrix of copper and tin. As a certain interval must necessarily occur between the time when the metal enters the mold and the time when it solidifies, the lead always shows some tendency, owing to its high specific gravity, to liquidate toward the bottom of the casting. In bearings made of the proper raw materials, and correctly handled, the difference in the proportion of lead is not usually over a fraction of one per cent., or at most 2 or 3 per cent., the top and the bottom of a casting, even if this be a fairly large one, and made of the 30 per cent. lead alloy.

The first requisite of a bearing is that it shall be sufficiently hard to support its load or to resist the impacts to which it may be subjected, and the relation of tin to lead must be controlled by this requirement. We have sometimes made mistakes in recommending the copper 65, tin 5, lead 30, alloy for certain mill bearings, but this did not have sufficient resistance to compression, and failed for that reason. When the copper 73, tin 7, lead 20 alloy was substituted the bearings exhibited no deformation and performed far better than the 80-10-10 alloy previously used. We have also noted the failure of the 73-7-20 alloy on rod bearings of very heavy locomotives. Locomotive rod bearings are subjected to severe impacts and it is necessary therefore to use an alloy of fairly high compressive strength. Although the above alloy performs satisfactorily on light locomotives, on the rod bearings of heavy locomotives it is necessary to use either the 80-10-10 alloy or the same alloy to which has been added approximately 1 per cent. of phosphorus, an alloy with 8 per cent. of tin and 1 per cent. of phosphorus will have compressive strength approximately equivalent to the alloy having 10 per cent. tin. Experience, thus, has demonstrated that alloys containing as little as 5 or even 4 per cent. tin and as high as 30 per cent. lead, can be used in railroad service for the densest traffic.

Let us next consider the possibilities of substituting some other metal for a part or all of the tin in a copper-tin-lead alloy, or of substituting alloys of an entirely different type.

The first metal that presents itself as a substitute for tin is antimony. Antimony combines readily with copper and with lead, and has the property of adding hardness. Unfortunately, however, the hardening effect of antimony is obtained with the sacrifice of ductility. We have found it possible to make alloys carrying as high as 30 per cent. of lead with 3 per cent. of tin and 2 per cent. of antimony. We have also made alloys of 65 copper, 30 lead, 2 tin, and 3 antimony, and have also replaced the 5 per cent. of tin in this alloy entirely with antimony. Car bearings 4¼ x 8 in. size made from the same pattern and subjected to a breaking stress applied longitudinally at the middle of the back of the bearing and throughout its entire length, broke at the following average loads: with 2 per cent. antimony substitution, 60,000 lb., with 3 per cent. substitution, 62,000 lb.; with total substitution, 52,000 lb.; as compared with a breaking load of 67,000 lb. for the alloy of copper 65, tin 5, lead 30. The castings produced with each of the three above-mentioned alloys are not so satisfactory as those made with the straight tin alloys, being more or less rough, and showing slight globules of lead on the surface. It has been found that a certain amount of nickel can be used for replacing tin with very satisfactory results. The castings produced when zinc is substituted for a certain amount of tin are decidedly unsatisfactory. The substitution of aluminum for tin is entirely impractical, and such castings are worthless. This does not, however, exhaust all the possibilities of substituting other metals for tin in the copper-tin-lead alloys, but it is my opinion that the substitution of any other metals, in those alloys, can be made only by sacrificing the quality or the alloy.

The possibility of substituting alloys of an entirely different type presents an attractive field for research. The copper-tin-lead alloy has attained its position as the most desirable bronze bearing alloy, but this does not mean that some other alloy may not be found which may give equally good or better results.

*An abstract of a paper by C. H. Clamer at a meeting of the Institute of Metal Division of the Am. Inst. of Mining Engineers; reported in *Chem. & Met. Engineering*.

Tar Oil in Diesel Engines

Almost all heavy tar distillates are suitable for use in Diesel engines. The gross heat value of tar oils of British origin averages 10.2 per cent less than that of the petroleum oils sold in this country, but the increase in consumption is not higher by this amount for the reasons that tar oil generally yields a higher thermal efficiency than petroleum oil (probably due to its lower viscosity), and owing to the average hydrogen content of tar oil being only about 6.9 per cent as against about 11.5 per cent for petroleum oils, the difference between gross and net calorific values is not so great as with petroleum oils. The average ignition point of tar oils is about 480° C. as against 260° C. for petroleum oils, and it is this difference which is responsible for the troubles in obtaining ignition of tar oils. With a normal tar oil, petroleum is necessary for starting with compressions below 670 pounds per square inch, but good running is obtained at over three-fourths load with a compression of 460 pounds per square inch. Shale oil is particularly serviceable as an ignition oil with pilot ignition gear on account of its low ignition point. High temperatures of the circulating water help the combustion of tar oil to a small extent. Heating the cycle air lessens output of the engine by rarefying the air, but aids the combustion of tar oils. Advancing the fuel valve is a distinct advantage. The best results have been obtained with 9 degrees advance when burning tar oil alone, and about 5 degrees advance when using pilot ignition gear (running engine at 250 revolutions). Mixing oils is of doubtful advantage, as it is necessary to employ more than half petroleum to obtain moderately good results, even when oils are such as will stand mixing without forming deposits. Hot blast is by far the most helpful modification for burning tar oil, but is rather dangerous, as it might cause explosions in the fuel valve casing. The fuel valve face suffers a little more with hot blast than in normal practice. Heating the fuel is useful from the point of view of increasing efficiency by reducing viscosity and as a means of dissolving naphthalene. Improved running on tar oil at low loads is obtainable by restricting the flame plate, but this is only at the expense of the full load results. Wear on exhaust valve is not very serious with tar oils, but is a much more important matter when burning raw tars. It only becomes serious when firing is uncertain, and is generally much worse when running on tar oil alone than with the pilot ignition system. Oils which give an abrasive ash on ignition may cause trouble even when this amounts to less than 0.08 per cent, but when the ash consists largely of sodium sulphate (arising from washing tar acids from creosote), much higher ash contents are permissible. Tar oils containing pitch cause many troubles, but it is almost entirely the free carbon which affects the use of such mixtures in internal combustion engines. —*Note in J. Soc. Chem. Ind. on a paper by H. Moore in Diesel Engine Users' Assn.*

Determining the Value of Slip

The following method of determining the slip is so simple that it is quite possibly already known. However, on account of its value and simplicity it is worthy of mention, seeing that it requires no unusual apparatus, and can also be applied to squirrel cage motors. The method does not tire the eye of the observer, and takes neither from the motor or the network any measurable amount of energy. Let us suppose a disc to be mounted on the pulley of the motor, and in it let there be a number of radial slits corresponding to the number of the poles. Through these slits observations are made on a frequency meter of the reed-vibrating type; then the reeds vibrate at a speed depending on the slip of the motor. Let the vibrations be counted over a measured period of time; then the slip can be calculated exactly as in the method which employs polarized apparatus like a galvanometer. It is best to direct attention to the reed which has the greatest vibration. If the swinging of the other reeds disturbs the observer, these can be shielded by some sort of a cover. The only instruments that are required are a frequency meter and a watch.

Some points may be mentioned about the disc, its construction and arrangement. Card or sheet metal can be used; this depends on whether the disc is in frequent use. For high speeds, paper is sufficient, as it is kept taut by centrifugal force. If the disc is painted with a matt black varnish, the vibrations of the white reeds are easy to observe. The slits should be slightly larger than the biggest swing of the reeds; possibly 15 mm. or 20 mm. is sufficient. The diameter of the disc depends on the method of fixing and also on the frequency meter. If a pulley is available the disc is best made of wood, bored out to the proper diameter. If the experiments are made on a motor, which drives through a belt, then the following plan can be recommended. Three or four small segments of sheet metal are prepared, which can be fixed in any radial position by screws, which fit in the slits. The segments are separated to such an extent that they lie on the inner side of the disc; the screws are then tightened, as soon as the disc has been centrally mounted. A third plan is to provide the disc with a three-edged tip, such as is used on speed-counters, the whole thing being capable of rotating on a hand-grip. But this is an uncertain plan, even if the center of the pulley is roughened with a chisel. If it is difficult to bring the eye into position for observing, an inclined mirror can, of course, be used. The method is specially suitable for small motors, since the air-friction of the disc is very small. The current required is very small, and amounts to about 30 milliamperes for the frequency meter. The arc lamp, which is used in stroboscopic methods, is not needed, and as it frequently takes more current than the motor itself, this is a great saving. —*Abstract of an article by G. Hilpert in the "Elektrotechnische Zeitschrift."*

Paper Driving Belts

Paper substitute driving belts are now being introduced into German workshops, and some particulars of them are given in the *Bulletin des Usines de Guerre* for July 1st. The paper is cut into narrow bands, which are then spun. The belts are made by weaving or braiding. Woven-paper belts are of two kinds—paper fabric belts and paper thread belts, the former type being the most frequently used. The fabric is first cut into bands 40 m. long, which are subsequently made up according to the desired width and thickness. A core of strengthening material is interposed, either cotton or sheet metal, though more recently these cores have consisted of paper thread and metal wires interwoven. The core is surrounded with the paper strips and the whole sewn with strong thread. Belts so prepared are said to be very flexible and to wear satisfactorily. Woven paper belts have a tensile strength of from 100 to 125 kilos. per centimeter of width.—*Engineering.*

The Position of Airships in the Future of Aeronautics*

The success recently achieved by large aeroplanes, and the comparatively poor results obtained by the airship as a war machine, has had the effect in aeronautical circles of creating a state of mind wherein the aeroplane is considered as the only air machine worthy of development for commercial or other purposes. In an endeavor to consider the question in true perspective, particularly in connection with the airship and its use for commercial work after the war, it seems desirable to put forward the following views and make some comparisons of the qualities and performances of aeroplanes and airships.

First: in order to make a fair comparison a correct idea of the relation between airships and aeroplanes in regard to size should be obtained. An aeroplane is considered big and to represent to the minds of those who have only dealt with aeroplanes a great achievement when its gross weight or lift is in the region of 6 tons; in fact 14 tons probably represents the limit of size that has yet been attempted with any degree of success. In comparison with an airship 14 tons is quite small; in fact, airships of five times this gross weight have been in use for some time in Germany, and it is quite possible that airships of 100 tons weight are on the stocks at the present time. Moreover, unless some radical changes in design are brought about in connection with aeroplanes, it is quite possible that an airship of 200 tons gross lift could be constructed with success much more easily than an aeroplane of 30 tons gross weight.

The effect of the comparative ease of designing and constructing a really large aerial machine as represented by an airship is seen greatly to advantage when considering the question of carrying capacity or useful lift. It is a remarkable fact that as a general rule the proportion of useful lift to gross lift is about the same for both aeroplane and airship of equally good design, being on an average about 33 per cent., ranging between 25 per cent. to 45 per cent. according to the quality of the design in both cases. Machines of special design when useful lift or speed is gained at the expense of some other attribute are, of course, ruled out of this comparison, otherwise one might quote an airship of small power and speed with a very high percentage of useful lift in comparison with a fast high-powered aeroplane with a very small proportion of useful lift. This fact puts the airship in a very favorable position as regards weight carrying, particularly for commercial purposes, since whereas a large aeroplane of 6 tons gross weight would only have a useful carrying capacity of 2 tons, a 60-ton airship can carry a useful load of 20 tons. Useful load in both cases is taken as representing fuel, crew, oil and cargo of commercial or military value.

The airship is generally referred to by those who would limit aerial development to aeroplanes as a big clumsy gasbag, but when a proper comparison is made of airship and aeroplane of the same gross lift or weight, it will be seen that there is no great difference in dimensions, particularly so if we try to compare an aeroplane designed to have, say, a gross weight of 60 tons with that of a 60-ton ship. For instance, suppose a 60-ton super "Gotha" were designed on the same lines as the present type—the area of the planes would have to be $\frac{60}{3.25}$ times that of the present Gotha, and therefore would be:

$$958 \times \frac{60}{3.25} = 17{,}700 \text{ sq. ft.}$$

since the lift is proportional to the plane area, and an ordinary Gotha weighs 3.25 tons, its plane area being 958 sq. ft. The overall dimensions on the bases of the linear dimensions being proportional to the square root of the area and thus of the gross weight would be:

$$\text{Span } 78 \times \sqrt{\frac{60}{3{\cdot}25}} = 334 \text{ ft. span.}$$

$$\text{Length } 41 \text{ ft.} \times \sqrt{\frac{60}{3{\cdot}25}} = 175 \text{ ft. length}$$

$$\text{Height } 12{\cdot}75 \times \sqrt{\frac{60}{3{\cdot}25}} = 59{\cdot}5 \text{ ft. height.}$$

It is admitted that it would be possible to considerably improve upon these figures by making multiple types which will decrease the lateral dimensions and increase the height; yet, when we consider that the dimensions of a 60-ton Zeppelin airship are only 650 ft. long, 79 ft. wide and 92 ft. overall height, it will be seen that the airship is at no great disadvantage in this respect. Further, if we reckon floor space occupied as length by breadth, the floor space occupied by the 60-ton plane is about equal to that occupied by the ship.

If we consider planes or ships of very large gross lifting capacity the advantage of smaller dimensions will ultimately be with the airship as the lifting capacity of the ship increases with the cube of the linear dimensions of the hull and that of the aeroplanes as the square of the linear dimensions of the planes. For instance, the dimensions of a 200-ton airship would only be 975 ft. long, 118 ft. diameter, and about 138 ft. overall height, whilst the dimensions of any aeroplane designed on present lines would greatly exceed these dimensions, even if such an aeroplane were possible to construct.

As regards air resistance and power required, the large airship shows to great advantage over the large aeroplane. This advantage arises out of the two facts: (1) That in an aeroplane a large proportion of the power is required in order to obtain the dynamic lift as apart from the direct resistance of the aeroplane to motion through the air, whereas an airship obtains its lift without expenditure of power. (2) The resistance of the hull, or lifting body, which is the greater portion of the resistance of a large ship, is in the case of the ship proportional to W 2/3 and in the aeroplane proportional to W, where W equals gross lift, and therefore, the greater W the less resistance of the lifting body of the ship in proportion. In the larger sizes the aerodynamic resistance of the planes alone would be much greater than the resistance of the whole airship.

In connection with (1) we may state that a well-designed aeroplane wing has a lift drift ratio of 1 to 15 and for a biplane construction 1 to 14, which means that the resistance to motion is 1/14th of the weight sustained or about 7 per cent. This is almost a constant quantity for whatever speed the plane is designed. To this must be added the resistance of all other parts of the machine an amount generally about equal to this making 14 per cent. in all of the gross weight.

Now a modern airship of 60 tons displacement has a resistance of about 5 per cent. of its gross weight at 65 m.p.h. and it will, therefore, be seen that the power required for a 60-ton aeroplane would be 2.7 times as great if designed for the same speed. Even at 90 m.p.h., which is a reasonable speed for a large aeroplane, the total resistance of the airship would only be 10 per cent., whereas the aeroplane would have a resistance of 17 per cent. of its gross weight at this speed. It must be admitted, however, that in order to carry the necessary power on a ship, to obtain this latter speed an undue proportion of useful lift would have to be sacrificed. The figures for the airship quoted above are obtained from the particulars of Zeppelin "L. 33," the power being taken at 1,500 h.p. and the speed at 65 m.p.h., and due allowance being made for propeller efficiency, &c., of 75 per cent. overall.

The aeroplane figures may be confirmed by calculating the resistance from the best gliding angle obtained by aeroplanes. The best gliding angle is generally about 1 in 8, and therefore the resistance at the gliding speed is about ⅛th or 12.5 per cent. of the gross weight. The speed when gliding at the best angle is however only about 0.7 to 0.8 of the maximum speed of the plane, and it will therefore be seen that the 14 per cent. quoted above is really low and the advantage of the airship is therefore greater in this respect. If we use Lanchester's results, *i. e.*, "that at the most economical speed the aerodynamic resistance is equal to the direct resistance," and also "that the most economical speed is the speed at best gliding angle" we have:—

Resistance at maximum speed

$$= \frac{12{\cdot}5}{2} + \frac{12{\cdot}5}{2} \times \left(\frac{1}{{\cdot}75}\right)^2$$
$$= 17.35 \text{ per cent.}$$

In this calculation the aerodynamic resistance is taken as being the same at both gliding speed and maximum speed and therefore equal to half the total resistance at gliding speed. This is not strictly true, and gives a result rather too high; actually 16 per cent. is more correct.

This question of power required for a given weight or size of aerial machine, will no doubt prove to be a most important consideration in the future development of aeronautics. It will be seen that in the light of present day knowledge, airships will always be superior to aeroplanes in this respect, particularly when we remember that Lanchester after carefully considering the question of the limit of possibility in this respect for aeroplanes gives such a limit as being possibly 10 per cent. at 90 miles per hour.

It is generally assumed that the aeroplane is essentially a much speedier aerial machine than an airship. We have seen however, in the foregoing paragraph that for the same speed a greater proportion of power is required for a large aeroplane than for an airship of the same gross weight. We also note, that, whereas in the case of the ship the proportional resistance or traction coefficient becomes less as the size increases (and consequently speed can be increased with size), we have at present, no reason to believe that large aeroplanes will be speedier than small ones; in fact, rather the reverse. There is every reason to believe that airships of 30 tons and over can be constructed having a speed of 80 miles per hour and a useful lift of 40 per cent. of the gross weight, which compares favorably with any aeroplane that may be proposed having a gross weight of anything approaching this figure.

As regards duration of flight, it should require no particular demonstration to show that the airship holds the field as regards duration both with respect to time or distance. The chief reason for this lies in the capability of the airship to cruise at quite a moderate speed with a very small proportion of its total horse power in use. The aeroplane as we know it must of necessity always expend the greater portion of its available horse-power in order to maintain itself in flight, and can only keep in reserve the portion that is required for climbing purposes which may be 30 per cent. to 40 per cent., and even this can only be done in good weather when rapid variations in wind velocity are not prevalent.

An airship may fly at half-speed with an expenditure of only about one-eighth of its total horsepower, as the traction coefficient at low speed is very small, whilst an aeroplane must always use sufficient power to maintain its dynamic lift.

There is no doubt as regards height attainable, the aeroplane will always hold considerable advantage over the airship. Provided means are fitted on an aeroplane, as they undoubtedly will be, to maintain the power of the engines and the efficiency of the propellers at high altitudes there would appear to be no practical limit to the height that may be reached. In the case of the airship, however, available lift must always be sacrificed if high altitudes are to be attained. The limit of height is reached when all ballast or equivalent is disposed of, and the quantity of gas is just sufficient to maintain the ship in equilibrium.

The practical limit would appear to be about 15,000 ft. and even then the ship would require to have almost 50 per cent. of its gross weight available as ballast or equivalent unless the ship is supported by dynamic lift afterwards. The latter procedure is possible and is, in fact, carried out in practice by swivelling propellers, or by keeping the ship under way until actual landing.

However, for commercial purposes the question of height attainable is quite a minor point, and unless particular atmospheric conditions are to be encountered or made use of, 5,000 ft. would be all that is really necessary.

A good deal of adverse comment is often levelled against airships by referring to the difficulty of landing and generally handling the ships on the ground. This difficulty will no doubt, gradually be overcome by the provision of mechanical aids for this procedure. In addition whilst the landing of an ordinary aeroplane is comparatively easy, there is no doubt that, as the sizes of aeroplanes increase comparable to the size of large airships, it is quite possible that the difficulties of landing and ground manœuvring will increase to such an extent that the airship may become the easier proposition, particularly when it is considered that the ship can always be brought to a standstill in the air before landing is attempted, but if a 60-ton aeroplane must land at something over 60 miles per hour there is likely to be considerable more difficulty than with one, say, of 3-tons weight.

The greatest objection to the development of airships is no doubt, the hydrogen problem. The large expenditure involved in the manufacture, storage and upkeep of supplies and necessary plant in order to keep the ships inflated and replenished with gas would seem prohibitive.

One great source of trouble and expense is now being eliminated. Owing to imperfection of the gasbags it was formerly necessary to refill with gas at frequent intervals in order to replace impure gas. We have now reached a stage where it will be possible to use one charge of gas per year, with, of course, the necessary replenishing to replace the slight leakage and loss when gas is discharged during flight. The danger of fire becoming disastrous as a result of the use of hydrogen may in time be eliminated by developing the use of an inert gas such as helium, but this is not likely to become a practical proposition for some time.

*From *Engineering*.

Photos by Underwood & Underwood

Growing choice tobacco in the shade under a cheesecloth covering

Curing choice leaves of tobacco strung on cords in a ventilated building

Tobacco—A Universal Necessity

Notes on Its Production and Manufacture

For years the use of tobacco has been a favorite subject for denunciation by the self-appointed reformer, and a certain class of professional men who have an itching to get their names before the public, but as time goes on the "tobacco habit" apparently becomes more strongly entrenched, and the custom is so universal, and the facts against it so weak, that its recognition has become a matter of course in every army and navy in the world, which is fairly good evidence that the soothing weed is not such a bad thing for human beings as some people maintain.

Most of the objection to the use of tobacco comes from people who disapprove of everything that they do not themselves do, and to support their arguments they cite exceptional and individual cases, which are always easy to find. A substance which is not only harmless, but even beneficial when use in moderation, may easily become injurious if consumed to excess; and in the same way that tobacco has been condemned it would be equally fair to denounce the use of almost every description of food, for the number of dyspeptic wrecks in every community vastly exceeds, both in number and condition, those who are in any way affected by the use of tobacco. Physical idiosyncracies also enter into the question, for, from some obscure reason, some people cannot tolerate tobacco in any form, and such cases are too frequently cited in support of the anti-tobacco arguments. On the other hand, there are people who cannot tolerate such an apparently harmless substance as rice, but no one thinks of condemning rice for such a reason.

Anything used to excess is harmful, and most things which we put into our mouths, or stomachs, are more or less beneficial when taken at the proper time, and in proper quantities; and such appears to be the case for tobacco, as it certainly furnishes a stimulant that the system craves, and its soothing effect on the nerves is recognized.

The cultivation of tobacco in this country is highly localized and confined to special districts. The largest acreage is found in Kentucky, with North Carolina next with about half the area devoted to the crop in Kentucky. Virginia is third on the list in quantity of production, and Ohio fourth. In the central-eastern portion of the United States the tobacco producing district is entirely located in Kentucky, Ohio, Indiana, Illinois and Wisconsin; while another distinct field is comprised between southern Massachusetts and Connecticut and Florida, in the states bordering on the Atlantic. Outside of these two sections the production of tobacco is insignificant.

While tobacco growing is a very profitable occupation it is not one that the uninitiated can expect to succeed in, as a very exact knowledge of conditions and methods is necessary. Soil, climate, methods of cultivation, harvesting and curing for the market all require special expert knowledge and experience, and although a "weed," tobacco raising demands more care than most any other product of the land.

The seed of tobacco is very minute, and it is estimated that there are over 300,000 seeds in a single ounce, but necessarily a great deal is wasted in sowing. The seed is sown in a carefully prepared bed, and the young plants protected from wind, sun, excess of moisture and sudden climatic changes, until in about two months they are big enough to be transplanted to the fields; and even then the plants must be given a great deal of care and attention if leaves of the best quality are to result. The gathering and curing of the leaves differs in different districts, and also according to the quality of the tobacco and the purpose to which it is to be devoted. As a rule the plants mature in about two months after they are transplanted to the fields, and as soon as they show signs of flowering, the buds are cut off to prevent the formation of seeds, and only the best formed and healthiest leaves are left to ripen. For the best grades of tobacco the leaves are picked separately as they mature and ripen, and these leaves are strung on fine cords to be hung in the curing barns, as shown in one of the illustrations.

The ordinary way of harvesting tobacco is to cut the stalk near the ground, and to allow the plants to wilt on the ground before taking them in, a sharpened stick being thrust through the stalks of several plants, and then stuck in the ground to support the leaves as shown in the photograph on the cover page of this issue. When the plants are properly wilted they are hauled to the barns, where the sticks carrying the plants are arranged on stringers so as to permit a circulation of air around the plants, and this curing process usually occupies about six weeks. Sometimes, however, tobacco is cured by artificial heat.

After curing the leaves are stripped from the stem and made up into small bundles, each tied by a separate leaf. These bundles are now laid up into a solid pile on the floor of the barn, and after a short time the pile begins to get warm, and to ferment. Great care is necessary at this time to control the fermentation process, and not to permit the piles to get too hot, as both the color and the quality of the resulting tobacco may be affected. After fermentation the leaves are sorted according to quality, and packed ready for shipment, and then put away in warehouses to age, for it has been found that the quality and flavor of all tobacco is greatly improved by lying a long time in a moderate and uniform temperature.

It has been found that some kinds of tobacco do better if grown in the shade, and this is especially the case with the varieties used for cigar wrappers. To meet this requirement a light framework, supported on posts about eight feet high, is erected over the fields, and over this is stretched a covering of cheesecloth, thus artificially shading the whole field.

Tobacco is used in many forms and fashions. It is smoked in pipes, as cigars and as cigarettes; it is used in the form of snuff to excite pleasant sensation in the nostrils, and "dipping," and the refuse is utilized for exterminating the parasites of plants, either by burning to produce smoke, or by making from it a liquid extract.

The tobacco of commerce is derived from a plant botanically known as *Nicotiana Tabacum*, and although the product of different countries, and different climates vary considerably in quality and characteristics, practically all the tobacco plants of the world have been derived from this one variety of Virgina tobacco. Climate and soil have important influences on the character and quality of the tobacco grown, as well as the methods of gathering and curing; indeed, tobacco of different characteristics can be obtained from the same field, if desired, by varying the manipulation, and this depends on how the leaf is to be used. Probably greater care is given to the production and curing of tobacco intended for cigarettes than any other, for cigarettes are sold on the actual merits of their smoking flavor, whereas other forms of tobacco are sold practically on their appearance. The purchaser of a cigarette cannot see what the contained tobacco looks like, and consequently is apt to consider its flavor critically when smoking it. On the other hand, the man who wants a mild cigar carefully selects it according to its color, and the subsequent evidence of his senses has little effect on the preconceived impression established through the eye. As a matter of fact the outside of a cigar is no practical indication of the character of the bulk of the material within, for although the wrapper may somewhat modify the flavor of the completed cigar (and a poor wrapper can easily spoil a good cigar) it is by no means an indication either of the strength or the quality of the cigar, as it constitutes a very small percentage of the material. Moreover, the light color is too frequently secured either by manipulation in production or by chemical treatment during manufacture, neither of which is calculated to improve the flavor of the material; and although a nice, light color is thereby secured, it by no means follows that either the wrapper itself, or the finished cigar is mild in strength. On the other hand, a fully ripe leaf is, as a rule, quite dark in color; but, contrary to the popular belief, this dark tobacco is not necessarily strong, and its flavor is much more apt to be smooth and fragrant than the leaves that have been picked before they are ripe, or bleached by the aid of chemicals. The short of the matter is that the public has deceived itself on the basis of external appearance so long that an entirely false standard has been established in the cigar trade.

For cigar wrappers particularly smooth leaves, with even texture and color, are required, and such tobacco is produced in comparatively few localities, so that wrappers and fillers are in most cases entirely different in quality and character, and much judgment is necessary to combine the different kinds of tobacco that enter into a cigar. One of the tricks of the trade is the use of flavoring matters in every branch of manufacture; and in the case of cigars one method is to treat the filler material with infusions made from the stems and other refuse of fine quality tobacco.

For smoking and chewing tobacco leaves having the proper characteristics are laid up into cakes, which are wrapped in smooth covering leaves and the cakes are pressed in molds in a powerful hydraulic press. Both of these grades of tobacco are usually treated with some flavoring matter, and often with a sweetening as well; and if a cut smoking tobacco is desired, the plugs from the press are shaved by machinery.

The trimmings, broken leaves and other refuse from cigar, cigarette and plug making, are utilized for making snuff, which is a long and tedious process, but snuff is falling into disuse, and the remnants that formerly went to this product now go largely into de-

coctions used in the other branches of manufacture, insecticides and other obscure uses.

It will be appreciated that the above is but a hasty outline of methods that require great experience and care, and which vary in every tobacco producing district and with every different quality of product.

That the use of tobacco has reached a point where it can hardly be considered a mere habit, but rather almost a necessity is evidenced by the important position it occupies in the supplies sent to our armies abroad, and the quantities distributed by our Red Cross and Y. M. C. A. Associations that are furnishing it to our soldiers in immense quantities, and it is one of the first things a soldier asks for. Medical authorities also testify to its beneficial effects when used in moderation; but, like many other things this moderation is not always observed, especially when consumed in the form of cigarettes which are individually so mild that the cigarette smoker is apt to lack appreciation of the cumulative effect of a large number, and, moreover, as the taste becomes cloyed, there is a great tendency to inhale the smoke in order to secure a sensation that has been lost through smoking an undue number of cigarettes. This is one of the bad features of the use of tobacco which is rightly condemned by everybody. But aside from this tobacco is approved of and consumed in practically every country on the face of the earth, and by every race, and it must not be forgotten that this much prized "weed" is a gift of America to the world.

Lantern Slides by Reduction

Now that sizes smaller than quarter-plate are so very popular, there is less necessity for the use of the camera for lantern slide making than was formerly the case. The little negatives allow slides to be made by contact, which will include the whole of the picture as originally arranged; and, this being so, the real necessity for using the camera method is removed. True there still are workers who hold that there can be a quality in a reduced slide which cannot be got by contact, though this belief seems to be disappearing, and there was never any very tangible evidence in support of it. With very small negatives it may even be advantageous to enlarge onto the slide; for it must be confessed that when among a number of full-sized pictures on the sheet some very small ones are interposed, there is an irregularity of effect which is not altogether desirable. While we do not recommend amateurs who are thinking of making lantern slides to adopt what we may call the reduction method—unless they have good reason, in the size of the original negative, for doing so—we hope no one who has such good grounds for using it will be deterred by any supposed difficulty.

The necessary arrangements are easily extemporised by anyone who has a camera which will take a lantern plate and has sufficient extension to allow the image to be focussed on the required scale. Even if the extension is not sufficient, it is usually no very difficult task to make it so temporarily. The work is done on a table at home, so that a cardboard extension piece to carry the lens at twice the usual distance from the plate, or a little more or less, can be constructed without much trouble.

Having such a camera, the only other special arrangement required is something to hold the negative and to illuminate it evenly from the back. The holder should extend beyond it for some few inches all round, so that the negative has an opaque border to it, as this helps to secure a clean, brilliant image. But there is no need to make the space between the negative and the lens light-tight, provided the front of the lens is protected from any direct illumination from the source of light.

A cardboard box without a lid, with an opening cut in the middle of the bottom, slightly smaller than the negative, makes quite a convenient holder when stood on its side. It may be provided with a frame and turn-buttons to hold the negative; but strips of thin wood and card serve just as well if arranged to form a couple of grooves in which it can slide across the opening. For film negatives the opening should be covered with a piece of plain glass to which the grooving can be attached.

It remains to consider the method for illuminating the negative. We cannot merely put a lamp behind it, as this would give a patch of intense illumination in a direct line from the lamp to the lens, while the rest would be dark. A suitably adjusted condenser would overcome this difficulty just as it does in an enlarging or projection lantern; but, owing to the scale on which the negative is reproduced, and the sensitiveness of lantern plates, this is not required. Some form of diffuser will do all that is necessary.

A piece of white card, or a board covered with two thicknesses of plain white paper, makes an excellent diffuser. White blotting paper is particularly suitable on account of its even texture and very high reflective power. The diffuser should be a good deal larger than the negative in every direction, and there will be found to be a distinct gain in the illumination if the bottom of the box, against which the negative is fixed, is also covered with white paper.

Hanging tobacco plants in a curing barn

Such a diffuser may be arranged at an angle of 45° with the negative and illuminated from one side, or it may be parallel with the negative, a few inches from it, and lamps arranged between the two. The object in either case is to ensure nothing but a very white, evenly-lit surface being visible through the opening which is to carry the negative when the eye is placed where the lens of the camera is to come.

With a couple of metal-filament electric lamps, or incandescent gas lights, placed one on each side of the negative, an even illumination is readily obtained. An alternative method is a single lamp, placed on one side for half the exposure and on the other for the other half, or else on one side for the whole time, with the reflector at an angle. With the reflector at an angle, one can use magnesium ribbon as the illuminant if preferred. Another alternative is to arrange the enlarging lantern so that a concentrated beam of light from it is thrown upon the reflector.

Whatever form of illumination is chosen should be kept to, as otherwise there will be a difficulty in determining the exposure, as this will be influenced very largely, not only by the strength of the light itself, but also by the details of the arrangements—the angle which the diffuser makes with the negative and with the light, the nature of the diffusing surface, and the distance of it from the source of light and from the negative respectively.

Instead of diffusing by reflection from a white surface, a translucent diffuser may be used. Ground-glass or tissue paper stretched on a frame or on a sheet of glass, or glass coated with matt varnish, will serve for this purpose. To secure even illumination at least two such diffusing screens should be used, separated from each other and from the negative by two or three inches. A sheet of white blotting paper, oiled or waxed to economise light, will also answer very well. Where an oil lamp is the only available source of light, a couple of such screens will be found to economise light as much as anything; and evenness of illumination is also helped a great deal by moving the lamp during the exposure, so that it shall be behind the left half of the negative for half the total time that is to be given and behind the right half for the rest of the exposure.

There remains another method to be mentioned, and that is to use the enlarging lantern as the whole arrangement. It calls for a very considerable extension of the lantern front when there is much reduction of size in making the slide, but many of the best lanterns are provided with extension for this express purpose. The negative is merely placed in the carrier as for enlarging, and the front is racked out sufficiently to allow the image on the required scale to be focussed sharply upon the lantern plate, which is attached to the enlarging easel. This plan allows the exposures to be reduced to a minimum.—*The Amateur Photographer.*

Measurement of Temperature at Great Depths

In order to observe the temperature at the bottom of the bore-hole of Saint Jean d'Hérans, the deepest boring in France, which attained a depth of 5,302 feet, a new process was employed, which, in addition to the accuracy of its results, possesses a degree of simplicity unequalled by any of the more complicated methods formerly in use for this purpose.

Two ordinary centigrade thermometers of the same make were cut off short at the point of their scale marked 40 degrees, as the temperature to be measured was judged to be well in excess of this amount of heat. After verification with a third thermometer as a standard to see that they were unaffected by the operation, they were lowered to the bottom of the bore-hole in a simple pervious case or sheath; one instrument was fixed in the inverted position and the other erect. They were kept for an hour at the bottom to take the temperature of the rock and were then raised to the surface. The result of this was as the temperature must have risen to above 40 degrees, that a certain amount of the mercury would have leaked out at the top of the tubes. The instruments were then plunged into a warm bath and gradually heated until the mercury remaining in the bulb rose to the summit of the tube, which on comparison with the third thermometer was found to be at 62.5 degrees in the case of both test thermometers. As the mean temperature of the locality was 12.5 degrees centigrade it became evident that the length of the geothermic degree for this spot was 32.3 meters (106 feet).

It is, of course, not necessary to warm up the thermometers in a bath as, when placed side by side with the standard thermometer, all that is requisite is to add to the 40 degrees, the point at which the tubes were cut off, the difference in the readings between the temperature recorded by them and the standard thermometer reading, if all three instruments are placed in a constant temperature. Some points are noticed with respect to the little globules of mercury oozing out of the thermometer tubes, and to the use of the erect and inverted instruments to check small errors due to this cause. It is stated that the shocks caused in the bore-hole in lowering and raising the thermometers are sufficient to cause the dispersal of the minute beads of mercury.—*Comptes Rendus, July 29, 1918.*

Rapid and Ultra-Rapid Tanning*

A Review of Processes for Preparing Leather

By Nicolas Flamel

"At a time when France is preparing for war, when her whole population is springing to arms, our book acquires a new importance. As in the early days of the French Revolution new processes are being devised for the manufacture of all kinds of leather since this material is indispensable for the use of all troops. The Séguins, the Sallerons and many others have made fortunes by the use of chemical processes formerly unknown; at this time it is a patriotic duty to reveal these in the following treatise relating to hides and leathers."

These words were written by M. Dessables in the introduction to the second edition, which appeared in 1830, of his book called The Art of Manufacturing and Improving All Kinds of Hides and Leathers. This statement was somewhat exaggerated at the time, since the war in question was merely the conquest of Algeria, but today it is unfortunately rather an understatement than an exaggeration. Though this work is now forgotten, I have thought it well to cite it because it is chronologically the third complete treatise which appeared in France upon this subject, and because it completes the admirable work of the astronomer Lalande with reference to rapid tanning.

Leather, a material with which everybody is familiar, but which no one has as yet precisely defined because its constitution is imperfectly known, is used in the army for the footwear and other furnishings of troops and for the harness of horses. Though we do not know precisely what leather is, we can readily understand by recalling its principal applications in warfare that it is quite as indispensable as metals or explosives. While it is consumed in smaller proportions it is less readily replaced. Several years are required to rear an animal of sufficient size to furnish a skin capable of being used for sole leather or for harness as well as meat for provisions. *But the poorer the method by which leather is prepared and the more hasty its manufacture, the more rapidly it wears out.* This fact is especially evident in the case of sole leather when this is required to be in contact with water for a long time. But our soldiers often spend several nights and days in trenches either full of water or at least very muddy.

Formerly the tanning of leather for the soles of shoes was a very long process; for this reason it was found necessary to hasten the process during the wars of the First Republic and later in those of the Empire. The honor of having invented a rapid tanning process is generally ascribed to Séguin, a Frenchman, whose family name is connected with a large number of remarkable inventions in the most various branches of industry throughout the last century, and also at the beginning of the present century in aviation motors.

In reality, however, he grouped, perfected and popularized processes already known in England and in France. In his book upon The Art of the Tanner, published in 1764, the astronomer Lalande, indicates the methods suggested for shortening the period required for tanning—namely: float tanning, preparation by means of extracts, the use of heat and of foreign salts, such as alum, utilized in our own day in mixed rapid tanning[1].

In 1777, Preiffer announced that the heaviest green hides can be transformed into excellent leather in from six to eight weeks without tan bark, by employing the products derived from the distillation of coal or turf under the influence of heat.

The hides, after being cleaned and rinsed in the usual manner, are immersed in vats containing a mixture of two parts of the first products of distillation and one part of rainwater or river water. The vats are heated till the liquid is tepid. At the end of twelve hours the hide can be easily scraped. They are then placed in a bath formed by continuing the distillation of the coal and diluting the products with one-fourth part of water.

But if Séguin was not the inventor of rapid tanning, he had the great merit of understanding its importance for certain uses and of attempting to perfect it. The swelling of the hides was effected by means of dilute sulphuric acid according to a custom already in use in England and proposed by Macbride; the tanning no longer took place in pits. The hides were immersed in previously prepared solutions of tanning and were kept separate. The hides were immersed in extracts of increasing strength, and in order to prevent the waste of the tannin the head and flanks were removed. This process was reported on favorably after tests during the French Revolution, accordingly the Séguin process was made use of on a large scale by order of the First Consul. . . .

The example set by Séguin was followed on all sides and in England especially an effort was made to accelerate the process of tanning. In 1797, William Desmond took out a patent for a process very similar to that of Séguin. The *Annales de Chimie* of which Lavoisier was one of the founders, reports that in the first three volumes of the *Répertoire des Arts* several tanning processes were included[2].

(1) A new method for tanning leather by Mr. Ashton; in place of vegetable astringents he makes use of mineral astringents, of natural or artificial preparations of copper, iron, zinc or sulphur, which are employed in the form of baths; by these means he prepares sole leather in six weeks and calf skins in half that time; (2) Leather rendered impervious to water by means of a mixture of siccative oil and metallic oxides for which certain resinous gums can be substituted with advantage; (3) Dr. Macbride's new method of tanning, consisting especially in the employment of lime water instead of ordinary water, and of dilute sulphuric acid; (4) A treatise by Swayne upon the utilization of oak leaves for tannin; (5) An improvement in the process of tanning by J. Tucker, consisting in raising the temperature of the bath.

In 1808, the Society for the Encouragement of Natural Industry appointed a Committee to examine the tanning process of Favier (earlier processes referred to above having been forgotten or fallen into abeyance), which attempted to shorten the operation without injuring the hide.

This committee reported that the leather tanned by M. Favier in two months was of good quality though somewhat too brittle and somewhat altered in bloom; they regarded it as being equal in value to much of that offered commercially.

These experiments of Favier and Salleron were, however, forgotten as those of Macbride and Séguin had been previously, and nearly forty years passed before rapid tanning again attracted public attention. About 1847 A. Turnbull[3], published a new process of tanning leather by chemical means, observing that the ordinary processes were both slow and costly. He remarked: "While it is true that various methods have been proposed with the object of economizing time in the process of tanning leather, the result has been obtained only at the expense of the quality of the leather." To shorten the process of tanning, Turnbull made use of sugar, giving the following explanation of his methods: "Sugar possesses the curious property of rendering lime soluble, and it is this property which I have utilized by immersing leather saturated with lime in a solution of concentrated sugar before subjecting it to the action of the tannin. When the leather has had the lime removed I place it in contact with the liquid employed for tanning, which I cause to pass through the pores of the hide by means of endosmose and exosmose. To prevent the formation of gallic acid, which dissolves the gelatine and alters the qualities of leather, it is only necessary to prevent the contact of the tanning liquid with air."

"My process is extremely economical as the following figures will show: In the present state of the art of tanning 50 kg. of green hides yield only 2,215 of leather; but it requires 150 kg. of oak bark to tan 25 kg. of leather and the operation lasts eighteen months. By my method fourteen days are sufficient, and I employ only 50 kg. of tan bark for the same weight of hides, while I obtain 30 kg. of tanned leather. In short, I can prepare 39 hides while by the old method a tanner is preparing a single one."

The advantages claimed for this new process of tanning are as follows:

1. A 20% increase in the weight of the leather and improvement in quality, because of the neutralization of the injurious qualities of the lime on the fibre of the skin.

2. A tremendous economy in time and a very considerable lessening of the cost.

For the purpose of rapid tanning it was necessary to prepare concentrated extracts. Durand[4], General Commissioner of Finance, made an official deposit in behalf of Welsford of a flask containing concentrated tannin, together with two specimens of leather obtained by the use of this substance after only a fortnight's maceration. This concentrated tannin is extracted from two shrubs, the myrtle and the mastic, which grow plentifully near Rome. The advantages it offers are the replacing of tan bark from the oak and other trees, its greater economy and its small volume which facilitates transport.

All the experiments described above failed of general adoption, and rapid tanning did not actually come into use until after the attempts at electric tanning made in various quarters. Wrongly or rightly, but probably wrongly, as experience has proved, it was believed that tanning might be accelerated by displacing the tannin by means of the electric current; the object aimed at was the causation of that migration of molecules which the experiments of Hittorf had brought to light. The idea was alluring. The Burio firm made an effort to tan leather by means of electricity, and created the art of ultra-rapid tanning. These tanners did not take out a patent until April, 1882, after several years of experiments. They recognized that the rapid tanning did not entirely penetrate the skin unless the extracts employed were highly concentrated. The creation of rapid or mixed tanning dates from this period. M. Placide Paltereau, the president of the General Leather Syndicate, described the results of the new processes in his report at the Exposition of 1900. Speaking of the beautiful leathers produced by slow tanning with oak bark he said:

"They combine the qualities of fine and close tanning (*due to the slow absorption of the tannin*) of bloom, of firmness without stiffness, and the smooth finish on both sides of the leather." . . .

Further on[5] in speaking of "the process of tanning moderately accelerated by tannic extracts and by oak bark or other tanning substances, separately or in combination," M. Paltereau thus expressed himself with respect to leathers tanned by the old oak bark methods, as compared with the modern rapid tanned leathers, saying:

"The cost of production is less than that of leathers made by the old process and the average quality and appearance are good, although they do not possess the bloom of leathers made with pure oak bark and have not so good a cross section; however, these are the leathers of the present, and they will be more and more the leathers of the future."

But M. Paltereau remained unconvinced with regard to the leather obtained by ultra-rapid tanning with tannic extracts, observing:

"As we have said before we do not consider that this sort of product constitutes a stage of progress, or that it answers a demand. We come to this conclusion because of the small favor it meets with on the part of consumers in most countries, and because the financial results of its employment are comparatively poor in most cases. The most that can be said for it is that it is a useful *resource in cases where there is an immediate and considerable need of leather, because of a state of war.* And even so it may be remarked that with constantly increasing production throughout the world, the stocks of tanned leather manufactured by other methods will probably be sufficient as well as much to be preferred. *I do not, therefore, recognize the utility of the ultra-rapid process, except in those remote countries where civilization is merely dawning and which are still ignorant of the proper transformation of leather.*

"I will conclude, therefore, by quoting the words of the learned Professor Procter, who is an authority, not only in England, but throughout the world, as follows: 'Leathers tanned by this method are rather hard than firm; it is quite possible that *good sole leather can never be produced by rapid tanning.*'"

The present war has only too fully confirmed the fears and opinions so well expressed by Messrs. P. G. Paltereau and Proctor, the great industrial authority and the great chemical authority upon leather, with respect to leather for soles. Harness leather, in which the chief quality required is resistance to tension, is a different matter. Even when dampened by rain this

*Translated from *The Revue Générale des Sciences* for the Scientific American Supplement.

[1]*Art du Tanneur* (The Art of the Tanner), Sec. 100, 200 and 274; 1764.

[2]*Ann. de Chimie*, vol. XXII, p. 103; 1797.

[3]*Ann. de Ch. et de Ph.*, 3rd series, vol. XXI, p. 74; 1847.

[4]*Bull. Soc. Encour.*, 2nd series, vol. VI, p. 190; 1859.

[5]P. 341 and 342.

leather is not constantly immersed in mud or water, as are the soles on the shoes of our soldiers; it does not undergo constant friction against gravel and pebbles and it is not pierced by nails; finally it is "fed," *i. e.*, it is oiled.

The problem is very different in the case of the soles of shoes. The poorer the quality of such leather the more rapidly it wears out and the sooner it must be replaced, and since it is not possible in time of war to prepare leather in sufficient quantities by the slow tanning process, it is necessary to use leathers other than tanned leather, and other materials besides leather, to avoid excessive expense and poor results.

It is interesting to enquire why the process of tanning is necessarily slow. In general, the speed of a chemical reaction between a liquid and a solid depends upon a certain number of factors, among which the following may be mentioned:

1. The active surface of the solid (porosity, fineness of grain, etc.).
2. The degree of concentration of the liquid.
3. The temperature.
4. The chemical energy.
5. The physico-chemical constitution of the solid bodies.
6. The agitation to which the liquid is subjected.
7. The electric energy in the case of conducting bodies.
8. The osmotic pressure.
9. The permeability of the wall.
10. The migration of the ions under the action of the electric current.
11. The pressure, etc.

If instead of a chemical reaction we consider a phenomenon in the domain of molecular physics, the same factors intervene with the exception of the chemical energy. It is probable that leather is a mixture of complexes, of combinations and of solid solutions, but tannins are substances whose reactions are but slightly energetic, and if we consider the raw skin as a permeable wall, as it is seen to be in the parchment utilized by Graham in his admirable researches on the subject of osmosis, then the cured leather is permeable in a much less degree. In exact proportion as the tannin penetrates the skin and transforms it into leather the penetration is rendered more difficult and consequently slower.

In vats there is no agitation and the temperature is not very high. The tannin, therefore, dissolves very slowly, and never in very large amounts, consequently the whole process of tanning is necessarily slow because none of the factors enumerated above exerts an action which is energetic and therefore prompt.

In the art of tanning a leather is considered to be well tanned, tanned to the heart, when it is entirely penetrated by the tannin, *i. e.*, when it no longer exhibits a *line of green leather*. This is the characteristic of leather tanned by oak bark. The tanner makes a section of the skin by the stroke of a knife and thus watches the progress of the penetration of the tannin. The leather is said to be tanned to the heart when its color is uniform throughout its whole thickness, showing that the tannin has fully penetrated it; but for this to take place requires eighteen months if the raw skins are thick and heavy.

It was natural to suppose that this penetration of the skin by the tannin was the sole object to be accomplished, hence there are numerous patents and a multiplicity of processes for achieving this rapidly. All these patents make use of increasingly concentrated extracts, of agitation, of more or less energetic heating of the extracts in case the agitation does not heat them sufficiently, and sometimes of acids or various other substances.

The employment of an increasingly concentrated tanning liquid is only a natural development of the old tanning process. If the skin is immersed in a tanning extract which is richer than itself in tannin, then by virtue of the laws of osmosis the tannin will pass into the skin; if the reverse is true the skin will lose part of its tannin, which will pass into the liquid. Agitation is so powerful in its effects that if necessary we could by this means cause the skin to be penetrated by sand. Finally, heat accelerates all the phenomena referred to above. As for the action of acids and of certain other substances, their object is to make the skin swell and thus facilitate the penetration of the tanning liquid. The reader may suppose that we are exaggerating the effect of agitation. Not so: In 1891 the firm of Stark & Co.[6], at Weisenau near Mayence, patented a process by which tannin was employed in the state of a powder, or a paste, and was incorporated by means of friction with raw skins merely cleaned and bleached. The tannin is absorbed in a few hours and the water exuded forms a paste with the tannin.

Another process makes use of increased pressure. An English patent[7] states that hides prepared in the ordinary manner are immersed in tanning liquids which are enclosed within a copper vat with very strong walls. The extracts are subjected to a pressure of from 5 to 6 kg., and the extracts are changed every twenty-four hours. In Italy a similar method has been patented by the Alimonda firm at La Spezzia. Sometimes the leather is compressed between cylinders placed in the tanning liquid[8].

Another process makes use of a vacuum[9]; in this the hides are first placed in an apparatus within which a vacuum is then produced, the tannin liquid being introduced later. The operation is repeated two or three times.

The effect of the pressure or of the vacuum is made still more active by rotation, as in the process described as "tanning by means of baths of increasing concentration and of pressure which is likewise constantly increased inside a revolving apparatus"[10].

In some cases not only acids but also salts and a wide variety of other compounds are added to the tanning liquid. Thanks to all these various means ultra-rapid tanning can be effected in less than forty-eight hours; but is the leather similar to that obtained by slow tanning? Present experience shows that this is far from being the case.

When tanning is less rapid than in the ultra-rapid process, and is accomplished in from three to six months, we have rapid or accelerated tanning whose products are intermediate between the preceding and those yielded by slow tanning. The question arises as to whether the values of these different kinds of leather can be determined before using, and whether the method of tanning can be detected. It is impossible to answer the first question; while long continued experiments have been carried on in an effort to settle this point nothing has as yet been published in regard to them.

It is no less difficult to answer the second question. In the beginning leathers tanned by extracts by means of rapid or ultra-rapid tanning naturally contain certain foreign substances, such as the salts, acids, and other things added to the extract. But the tanners have now stopped using substances which are easy to discover by means of analysis, and the acids used to cause swelling are organic acids which not only cost less than sulphuric acid but which exist naturally in the extracts or in the hides themselves, and, therefore, cannot be so easily detected. There remains another difference between slow tanned leathers and leathers tanned more or lss rapidly by means of extracts, *i. e.*, in the latter case the leather contains a larger quantity of soluble tanning substances than in the former case. This difference, which is considerably lessened by the dressing of the leather, has now entirely disappeared. New processes of rapid tanning permit the penetration of the leather just sufficiently to *tan it to the heart*, without leaving any excess of tannin soluble in water. The tanners who do rapid tanning by their old processes, and, who, therefore, leave an excess of tannin not fixed by the skin, and which is, consequently, soluble in water, need only to wash their leather with water in order to remove the compromising excess of tannin, and their leather will then cease to appear to have been tanned rapidly. Unfortunately, however, they do not thereby increase the worth of their leather.

[6]*Br. St.* (Patent recorded), 2,871, April 4, 1891.

[7]20,154, Sept. 11, 1896. R. W. James at London.

[8]*Br. Allem.* (German patent), 98,342. Dec. 22, 1896. Georges de Ceyter, at Mouscron.

[9]English patent, No. 8,131, April 5, 1898. Scote at Liverpool.

[10]German patent, No. 103,398, July 6, 1897. H. Schmidt at Hamburg—Uhlenhorst and J. Landini at Hamburg.

The Physical Constitution of the Sun

(*Continued from page 403*)

tire absorption by the ground and the air. For the other planets the amount of heat received is in inverse ratio to the square of the distance, and the temperature in inverse ratio to the square root of the distance. From this it has been deduced that the maximum temperature upon Mars must be 24° C. below zero at the equator. This is the temperature which the earth would have if transported to the same distance as Mars. The entire planet would be frozen and the existence of vegetation impossible. But biologic evolution began in Mars two hundred thousand years before our own, and its inhabitants must long have been capable of successfully struggling against cold and of manufacturing sugar and other foods, etc., by direct processes.

Upon Venus, on the contrary, which is closer to the sun, the temperature would be 90° C. (194° F.) at the equator and 70° C. (158° F.) even in the latitude of 45°. These conditions represent those of the earliest geologic periods upon our globe. Hence Venus must be completely surrounded by a thick stratum of clouds. This is the reason why its surface has a considerable power of reflection, like that of the clouds. Mercury, finally, which is still closer to the sun, would have a temperature of 220° C. (428° F.) at the equator and of 190° C. (374° F.) in our own latitude. The water of its seas is probably not yet condensed and the geologic periods cannot have begun[10].

Let us now return to the earth and look back into the past to some degree. As we have seen, the sun was larger and hotter. The temperature of the earth naturally felt this. Assuming a constant linear dilatation[11] we obtain 113° C. (235.4° F.) at the equator and 100° C. (212° F.), even in the latitude of 29°, some 850,000 years ago. At that time the sun had a temperature of 7,200° C. and a radius only one-tenth greater. Let us go still further. When the sun had a diameter greater by two-tenths its temperature was 8,400° C., while that of the earth reached 200° C. (392° F.) at the equator and exceeded 100° C. (212° F.) at as high a latitude as 67°. Life was possible only near the poles, where there was a truly tropical temperature.

We see, therefore, that it is futile to have recourse, as did the eminent geologist de Lapparent, to the theory of a very large sun, *i. e.*, to exceptional physical conditions, in order to explain the geologic periods and the extension of the tropical flora even to the poles. It is futile also to speak of hundreds of millions of years to explain the sedimentary deposits of these geologic periods. The solvent power of rain water was 100 times as great then as now with respect to its temperature. Its power of erosion was 100 times as great because of the enormous daily evaporation, which nightly condensed in torrential rains, forming immense rivers 50 to 100 km. wide and dragging down mountains of debris in their muddy waters. A million years, and that is even enormous, would have sufficed to accomplish the work of sedimentation which in present conditions, but in those alone, would perhaps have required hundreds of millions of years. The work done does not depend upon the time employed but upon the power expended, and this expendable energy, which is derived from the heat of the sun, remains the same, whether utilized in a hundred million years or in one million. It would be utilized even more completely under the last hypothesis[12].

In the same way we can calculate the evolution of the temperature of the earth in the future. The sun will grow smaller and cooler. Thus in 160,000 years, when the radius of the sun has diminished by only one-hundredth part, our temperature will be not more than 26° C. (78.8° F.) at the equator. It will have fallen to 0° C. (32° F.) at the latitude of 46° and at Paris it will be below zero (centigrade). Finally, in 850,000 years, when the radius of the sun has lost only five one-hundredths of its diameter and merely 500° C. of its temperature, the temperature at the equator will have fallen to zero centigrade and the entire earth will be frozen. Biologic evolution, which ascends into the past for a million years may descend into the future for an equal period of time.

Moreover, the energy of the sun, whence proceeds our terrestrial energy, will be then diminished by only one-tenth. Mankind will doubtless by that time have long been capable of capturing this energy directly, of transforming it as the chlorophyl of plants so admirably does, of making it serve perhaps for several million years longer to sustain his life and the development of his thought.

But the most recent geological determinations place the advent of man, at least in our lands, at from twenty to thirty thousand years ago. Humanity is in fact then still very young, and nearer infancy, indeed, than youth. What magnificent achievements are reserved for us in its maturity! Its development strode forward at the pace of a giant, with a speed of manifold daily increase before the new invasion of the Barbarians. But in spite of all we can and must believe still in the force and the ultimate victory of ideas.

Science teaches us that the dreams of yesterday, the Utopias of today, will be the realities of tomorrow. We have had wings less than twenty years and already the airplane seems old. Tomorrow will be what we have made it, what we have willed it to be. All that is best must be made not only possible but necessary, and finally become a reality.

[10]*Comptes Rendus*, Nov. 5, 1917, vol. CLXV, p. 629.

[11]With a constant cubic dilatation the time and radius would be a little diminished.

[12]See *Journal de Chimie physique*, vol. XV, No. 1, March 31, 1917; The Physical State of the Sun, p. 40.

The Nocturnals of the Renaissance* and Their Decorations

By J. Tavenor Perry

MODERN mathematical and scientific instruments do not lend themselves to embellishment by relief or engraving, their makers rightly regarding any ornamentation as likely to interfere with the distinctness of the various lines or scales marked upon them, and thus mar their utility as implements of precision. But such decoration on clock faces and that of the inner cases of watches survived nearly to our time, though the "engine turned" watch backs seem to be the highest artistic effort of present-day horologists; but the chief reason for its disappearance is the fact that the instruments which are the most suitable for any adornment, the sun and moon dials, the perpetual calendars on metal, and the nocturnals, have themselves fallen into desuetude.

The class of instruments to which we have referred as presenting surfaces free for ornamentation were usually constructed of thin plates of metal, sometimes rectangular, but more generally in the form of disks, and these disks were often, according to the nature and the particular apparatus, grouped in layers of two or more revolving on a common centre, and being placed close together, the upper one passing over the face of the lower one, the decoration was limited to engraved lines or relief ornaments sunk back from the face of the disk, the reliefs being generally confined to the signs of the Zodiac placed in medallions hollowed out to receive them. But there were a number of attachments to these disks by which they were moved round,

Fig. 2

as well as index arms, and the handles by which the whole instrument was held when in use; and it was upon these, not subject to the same limitations in the matter of projection, that so large an amount of ornament was frequently lavished as to make them worthy of consideration for their artistic beauty rather than for their scientific utility.

A description of the character and use of the instruments is necessary as an introduction to any account of their decoration, and an examination of the very simple nocturnal made at the end of the sixteenth century by Humfrey Cole, and now in the British Museum, of which we give a drawing (Fig. 1), will best serve our purpose; and to this we will add a guide to its use published at the same date in Thomas Fale's "Horologiographia." Cole's nocturnal consists of a circular disk of brass $3\frac{3}{4}$ inches in diameter, having attached to it on each face other and smaller disks revolving on a pivot, which is pierced through in the centre sufficiently wide to permit of the observation of a star. The greater disk has the edge of the face divided into the months and days of the year, while the superimposed one is divided at the rim into the twenty-four hours of the day and night, and has the edge notched like a saw with teeth, two to each hour, the intermediate one for the half-hour having the less projection, so that it was distinguishable by the finger at night. This second disk is moved by a projecting handle, issuing at the point of midday, and with a sun-face engraved upon it; while the field of this disk, within the margin, contains the only decoration of the piece. Over all is a third disk to which is attached a long arm moving freely, one straight side of which coincides exactly with the diameter of the circle.

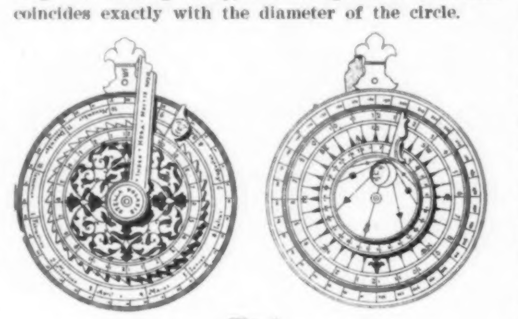


Fig. 1

The reverse of the great disk is divided on the outer margin into the 360 degrees, next into the twenty-four hours, and within these are shown the points of the compass. A second disk over this is divided into thirty for the days of the lunar month, and is moved by a small point radiating from the thirty; and a third disk, moved by another projection, is pierced with a circle placed between the centre and the circumference, which discloses the face of the sun, of the same diameter, in its revolution, and is intended to mark the phases of the moon. This disk is also scored by lines radiating from a point on the circumference above the piercing which are marked by the triangle, the square, and the six-rayed star, to indicate the trine, quartile, and sextile of astrological import. These marks for the use of astrologists are often found on lunar dials, and appear on that made for the Earl of Essex in 1593 by James Kynuyn, "of London, neere Paules," and they show on the disused lunar dial fixed outside of the south-west tower of St. Margaret's, King's Lynn, set up as late as 1687. The handle for holding the nocturnal, marked with a "W.F.," presumably the name of its owner, is fixed to the great disk at the south point of the compass, so that when it is taken in the hand for use its position is the reverse of that shown on our drawing.

The manner of using the nocturnal is set forth in the "Horologiographia"[1] of Thomas Fale, a physician and matehematician, whose work passed through sev-

Fig. 4

eral editions, and we will quote his exact words and phraseology:—

"When you would know the houre of the night by this instrument, doe thus: Place the right line of the long tooth of the 12 houre directly over the day of the moneth, and turne the handle on the back side to the hole of the greater beare, and your instrument perpendicularly, so that it declineth on neither side: and beholding the Polare Starre thorow the hole in the centre moue the ruler aboue until the right line thereof be directly against or seemeth to touch the two Starres of the greater beare and under the line you shall have the just houre of the night: which you may find out by the number of the teeth with your finger in the night. But if you cannot see the two Starres of the greater beare because of clouds and yet you may see the Polare Starre and the Starre of the lesser beare remove ye handle on the back side to the hole of the lesser beare. Then lift up your instrument as before and behold the Polare Starre at the hole and turn the ruler to the foresaid Starre of the lesser beare, and you shall find the true houre of the night, as is before taught."

No attempt at ornamentation of the earlier nocturnals, either English or foreign, seems to have been made, with the exception of the one by Humfrey Cole already described; and in the numerous works on the subject the diagrams given show nothing of the sort further than some slight elaboration of the handle. In Roias' book on astrolabes, published in 1550,[2] all the disks he shows have alike merely a simple strap ornament with a head to form the handle. The disks shown in the English publications of the seventeenth century, such as Blagrave's "Art of Dialling,"[3] and Moore's "System of Mathematics,"[4] are equally devoid of all

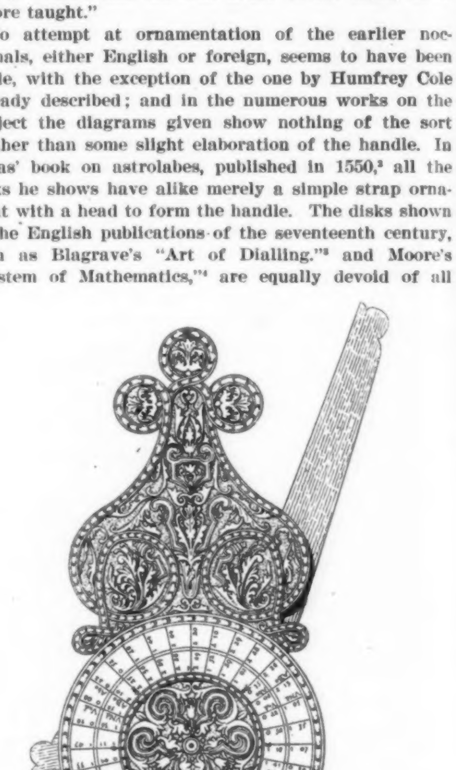


Fig. 3

decoration; while the brass universal dial and nocturnal made by Gaspar Vopel of Cologne, and dated 1551, now in the British Museum, except for a broad band engraved with the outlines of the constellations forming the Zodiac with their principal stars, has no embellishment whatever.

It would seem, however, that the first attempts ever made to give an artistic finish to mathematical instruments were due to German engravers, of whom the most important, or at least the best known in connection with this subject, were Wenzel Jamnitzer of Nuremberg, and Erasmus Habermehl of Prague, both of whom worked at the end of the sixteenth century. The former of these, called by Dr. Max Maas, "The German Cellini," left a MS. completed in 1585 (now stored for safety's sake in the vaults of the Victoria and Albert Museum) giving an account of instruments used in astronomical and other sciences. His portrait by Jost Amman shows him with a planisphere in front of him engraved with lines only, but we cannot point out any example of instruments decorated by him; and we can only assume that his decoration was confined to engraving, for his contemporary Habermehl, who worked well into the next century and turned out a large number of very beautiful scientific instruments, some of

*From the Architect and Contract Reporter.

[1]Thomas Fale, "Horologiographia, the Art of Dialling," 1597 (in black letter).

[2]Johannes de Roias, "Commentariorum in Astrolabium," &c. Lutetiæ. 1550.

[3]John Blagrave, "The Art of Dialling," 1609.

[4]Sir Jonas Moore, "A New System of Mathematics," 1681.

which drifted into the Strozzi Collection, rarely, if ever, showed any relief ornament on his productions.

By the end of the seventeenth century we find that mere engraving had been superseded by work of relief, as in the fine dial on a rectangular plate, No. 171 in the Spitzer Collection,[5] which bears the inscription "Fecit Engelbrecht Beraunæ in Bohemia, 1684";[6] and there must have been much transition work between the two modes of treatment not now easy to identify. During this period the nocturnal underwent considerable changes in its form; the handles were greatly increased, so as to admit of considerable space for decoration, the index arm was made much more important, and the smaller projections for moving the disks became ornamental accessories; and the simple instruments, like that of Humfrey Cole, gave place, without impairing their utility, to elaborate and artistic productions such as those with which we illustrate this paper.

As a good example of one of these decorated nocturnals we give, in Figs. 2 and 3, the obverse and reverse of a specimen in chiselled and engraved steel now in the Science Museum, and acquired for the Department in 1879. Its provenance is unknown, although in the description it is ascribed to this country, merely, apparently, because of some of the lettering inscribed on it. A comparison of it, however, with the square dial already referred to by Engelbrecht of Beraun will give reason to consider the work as German; but if, in the absence of any inscription, it cannot be ascribed to him, at least it may be to one of his contemporaries. The treatment of the Zodiacal signs in the cartouches, as well as much of the engraved ornament, is identical with his work, the difficulty being that the words "abo" and "und," repeated four times on the reverse, and presumed to stand for "above" and "under" respectively, as well as the letters "G.B." and "L.B.," for Great Bear and Little Bear, are not German, though these could easily have been added after it came into the possession of an Englishman. A further difficulty is in the use of the letters "O.," "S.O.," and "N.O.," on the reverse, for West, South-West, and North-West, suggesting rather a French origin, and causing it so to be described in earlier editions of the catalogue; but it is perhaps easier to explain away this difficulty also than to accept the design as either a French or English conception. It must be pointed out in reference to the markings on the reverse that they were intended to aid in determining latitude by observations of the positions with reference to the Pole Star of the stars in the Great and Little Bears. The diameter of the dial is 6¼ inches and the total length of the piece over the handle is 14 inches.

Another example of chiselled steel work which we give in Fig. 4 is altogether different and more artistic in its treatment than the last, and of even more uncertain provenance. There was one almost identical with it in the Spitzer Collection, the main difference being that mermen are substituted for mermaids in the centre of the handle, and M. Ernst describes it as French work of the seventeeth century. That one, as well as this, has had the centre hole stopped up with a rivet, destroying its use as a nocturnal, and the piece was then described as a perpetual calendar. This particular nocturnal appeared for a time in the sale rooms of Messrs. Lempertz, of Cologne, in 1887, and its present resting-place is unknown to the writer. It measures across the dial 7 inches, and its total height is 11½ inches.

A nocturnal in the Victoria and Albert Museum, of which we give a drawing of the face in Fig. 5, though in chiseled steel, is of so remarkable a character as to cause it to be ascribed by some to an Oriental fabrication. The creatures forming the index arm and the handle are chiselled out in the round, the scales of the beast near its head on the handle, as well as its mane, being bent out with a curved serrated edge. Many of the lines on the dial are damascened in silver, and the band of little dots near the margin is worked in gold. This was bought in 1893 for the Department at the Spitzer sale, and M. Ernst describes it in his note as English work of the sixteenth century, while the Victoria and Albert Museum catalogue describes it as a late seventeenth or early eighteenth century production. Curiously enough, the Science Museum possesses a replica of this, without the damascening, in gilt brass or copper. The diameter of the dial is 4 3/8 inches, and the length over the handle 8¾ inches.

The last example which we give in Fig. 6 is also from the Victoria and Albert Museum, and was acquired by purchase in 1879. It is of copper gilt, pierced, chased, and engraved, of very delicate finish, and considered to be French work of the seventeenth century. One almost identical, if not a replica, was

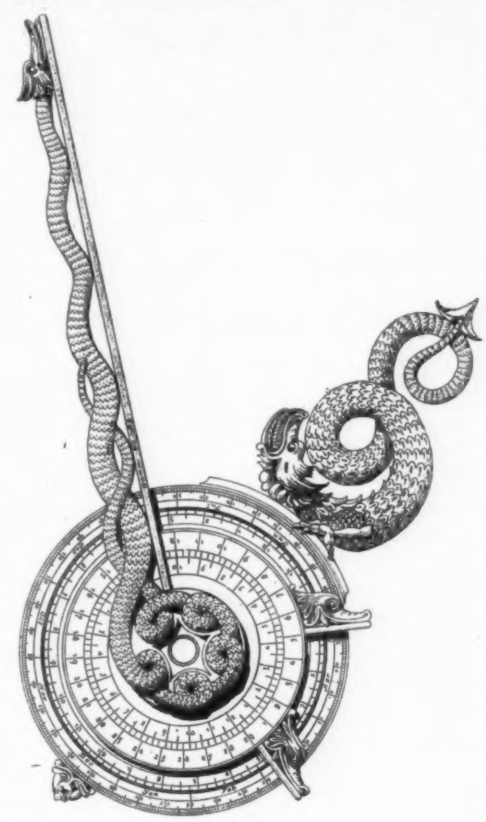


Fig. 5

sold from the Spitzer Collection in 1893. The diameter of the dial is 5 inches, and length over the handle 12 inches.

We are fortunate in possessing in London so many examples of these curious instruments of a bygone

Fig. 6

age; it is not a little singular that the earliest and plainest work of the Renaissance period is to be found in the Mediæval room of the British Museum, while the Science Museum contains many of most artistic work, and the Victoria and Albert Museum has but two, both of which we illustrate.

[5]La Collection Spitzer. "Les Instruments de Mathématiques." Notice par M. Alfred Ernst.

[6]It is interesting to note that a brass movable sun dial in the Science Museum bears the same inscription, but with the date of 1784, thus showing that a member of the same family was engaged in similar work in the same town a century later.

Usefulness of a "Movie" Camera for Photographing Phenomena of Solar Eclipses

By Edwin B. Frost

The photographic records of the flash spectrum at a solar eclipse have hitherto been composites of the rapidly changing appearances of the lines during about two seconds, at second and third contacts. In view of the present commercial perfection of the motion picture cameras, it seemed to the writer worth while to attempt to secure, with their aid, a record of the phenomena at short intervals during those two seconds.

The spectrum was formed by three large prisms of Mantois glass, placed in the beam from the coelostat. Behind the prisms came the camera lens, made by Brashear for another purpose, with aperture 50 mm. and focal length 400 mm. The image of the spectrum fell on the film of the motion picture camera, from which the usual short focus lens had been removed. The crank was turned by Mr. Blakslee at the rate of two turns per second giving 16 exposures per second, each of about 1/30 second duration.

Heretofore there has always been danger that the exposure for the flash would be made too soon or too late, even if the signals are given by an experienced person observing visually with another instrument for that purpose. But with the motion picture film, it is entirely feasible and desirable to begin exposures in ample time before totality; and to continue them until a few seconds after totality has begun, and conversely at third contact. Thus there can be no danger of missing the flash at either contact, and a record is given of the reversing of the lines of higher level, which occurs many seconds before the real flash.

In this case (June 8, 1918, at Green River, Wyoming) I had the exposures begin 60 seconds before second contact, and continue until about 5 seconds after totality had begun; the film was then kept at rest for about 80 seconds to secure the spectrum of the corona; then started again 5 seconds before third contact and run for an additional minute. About two hundred feet of film were thus exposed, and a thousand or more impressions of the spectrum were obtained. Unfortunately the clouds that were passing cut off all fine details of the flash, leaving no impression for many exposures at the beginning of totality; and the record indicates the coming and going of the clouds; for the last 30 seconds the sky was nearly clear and the spectra are over-exposed. Bright gamma of hydrogen is seen on many exposures. It would seem to be safe to make the exposures even more rapidly at another eclipse favored with a perfectly clear sky: I estimate that 1/50 second would suffice for an exposure time with this apparatus. The later exposures, through a better sky, show excellent definition.

An attachment was arranged to give a small black dot at one corner of the film at every beat of the chronometer, which operated a small eletcric flash lamp. Thus the time could be inferred accurately for all exposures.

It would be easy to turn the camera by motor at a precise rate and to connect it with a chronograph, if desired.—*Popular Astronomy.*

Elimination of Secondary Radiation in Radiography—The Antidiffuser

Distinct radiographs of the thicker parts of the body are very difficult to obtain owing to the amount of secondary radiation which occurs. The apparatus here described has been designed with the idea of cutting out the effects of this secondary radiation and so enabling radiographs of the body to be obtained comparable in definition with those of the hand, etc. It consists essentially of a chassis moved by clockwork upon rails, under which the photographic plate is introduced, the subject to be radiographed being placed upon a board, covering the chassis. The plate and subject remain at rest, the chassis only being movable. The action of the secondary radiation is annulled by thin sheets of lead suitably placed in the chassis. The method of using the antidiffuser is described, and diagrams illustrating its construction are given. It is claimed that radiographs taken with the aid of this appliance, using screens and hard radiations, and without undue narrowing of the image, give entire satisfaction to photographer, radiographer, and surgeon alike.—*Note in Sci. Absts. on an article by Tauleigne and G. Ma o, in Arch. d'Bl. Medicale.*

Antiseptic Value of Peat

Peat produced by the decomposition of sphagnum moss is so antiseptic and absorbent that it may be used as a dressing for wounds, and is an excellent substitute for medicated cotton. This fact has been recognized for some time in Europe, where sphagnum moss is now extensively used in preparing surgical dressings. According to Prof. Soper, there are large tracts of sphagnum bog in the northern counties of Minnesota, Wisconsin, and Michigan, also in Maine, and some is found in New York and Pennsylvania. No deep excavation would be necessary, for immense quantities of sphagnum can be taken from the upper parts of the deposits.—*Coal Age.*

Statistical Studies of Dietaries*

The matter which is essentially new in this interesting and valuable report by Viscount Dunlace and Capt. Greenwood is a statistical study of the diet of workers fed in hostels and canteens attached to various factories under the Ministry of Munitions. The document also contains an independent analysis of available figures relating to working-class dietaries before the war, and it is prefaced by an exceedingly interesting appraisement of the practical significance which is attached to the results of modern experimental work on dietetics.

A careful study of food consumption under the conditions of canteen feeding must yield a valuable document. When, as in the majority of cases dealt with in this report, the whole nourishment of the individual is derived from an official food supply, the data become more trustworthy than those of most statistical studies, and there is the additional merit that individual consumption is not forced or otherwise affected by a predetermined ration such as exists in the Army. A further advantage is that the work done by various sections of the community, though not actually measured, nor perhaps measurable, is at least of a recognisable order of severity.

The average daily consumption "per man" of some 20,000 munition workers during the spring and summer of 1917 was found to consist of 115.7 grams of protein, 141.3 of fat, and 408.4 of carbohydrate. The average calorie value of the food was 3,463 ,a figure very near to the standard so generally accepted for a man doing moderately severe work. All the figures refer to food "as purchased."

The statistical method applied to nutritional studies has obvious limitations as a guide to practice, especially if guidance be sought when, as now, the national conditions are exceptional. Its results display the influence of appetite limited chiefly by economic conditions. If the latter are unfavorable, statistics of consumption do not guarantee the measure of an efficient diet. If conditions are favorable, the statistics may offer no guidance for economy. In this connection, however, the above data are perhaps more than usually trustworthy. The munition workers were well paid, but in the earlier months of 1917 there was an atmosphere tending to check extravagance, though as yet there was no feeling that the individual should go actually short. It is interesting to find, therefore, that the energy consumption was so closely similar to that of the working classes before the war. The average figure for the latter, as re-calculated by the authors from the Board of Trade returns, was 3,571 Calories.

The dietaries of munition workers were, however, in a qualitative sense, abnormal, especially in the very high proportion of fat eaten. In this respect they cannot serve as a model for the present or for the immediate future. This high consumption of fat resulted from the circumstance that the time when the statistics were being collected an acute shortage of potatoes co-existed with a vigorous "eat less bread" campaign. In one hostel, where the "voluntary" weekly bread ration of 4 lb. was literally accepted, the fat consumption rose to 214 grams a day! As the authors remark, this is a sufficiently instructive instance of what happens when the nutritional habits of the population are disturbed by force of circumstances or otherwise.

There is great difficulty in choosing a final expression for the results of statistical studies on the diet of a community. The demands of men, women, and children respectively have to be brought to some common denominator. This is usually done by expressing them all in terms of "man value." To take a woman's demands as eight-tenths of a man seems justified by the best data available. Much less satisfactory, however, are the factors hitherto used when growing boys and girls are concerned. To take the requirements of boys at thirteen as being 0.6 and of boys at fifteen as 0.7 of a man's (Atwater and Bryant) is certainly an error. The measurements of basal metabolism made and collected by Dubois, for instance, show that the requirements are proportionally high at these ages, so that a boy of thirteen wants little less food than his father, if the latter be a moderate worker. F. Gephard found, indeed, that the consumption at a large boys' school in Concord, New Hampshire, was nearly 5,000 Calories per head per day.

This question is not fully discussed by the authors of the report, who, following the Food Committee of the Royal Society, used the Atwater factors. They show, however, in an appendix, to what an important degree the recognition that the demands of children are larger than was thought will affect current statements as to consumption "per man" when family budgets are dealt with. For example, taking the normal family of man, wife, and four children, the man value usually taken is $1 + 0.8 + 4 \times 0.51 = 3.84$. Taking the factor for children as 0.7 instead of 0.51, the man value becomes 4.6 and the *per caput* man consumption is reduced to 83.5 per cent. of its usually tabulated value. At any rate, a proper recognition of the requirements of children is of immense importance in budgeting for the nation.

Unfortunately, statistical studies do not tell us what at the moment it is so desirable to know. How far can the customary diet of a community be reduced without reducing its output of work? If reduction in food merely means inconvenience or even a degree of suffering, the nation will not fear it. What it has to fear is a consequential diminution in productiveness.

Even experimental studies have not yet given a satisfactory answer to the above important question. We know that if an individual under favorable conditions of nutrition will accept with equanimity a certain loss of body-weight, he may considerably reduce his consumption without obvious loss of health, and, to judge from the work of Graham Lusk, his "efficiency" in the technical sense will not be affected. Work actually done will apparently be done at the same cost in Calories. We have, however, no certain knowledge as to how far that reduction can go (if it can occur at all) without affecting his ultimate capacity for work.

The review of modern experimental investigations with which the report opens well repays perusal as coming from authors highly qualified to appraise it from an independent point of view.

In connection with the experimental measurement of Caloric requirements, they do well to emphasise the point which Dr. Leonard Hill has recently made so clear—namely, that estimations made upon a man in a calorimeter at uniform temperature and in still air must not be applied in practice without proper qualifications. Vary the conditions, lower the external temperature, and especially increase the movement of air to which a resting man is exposed, and the demand goes up. It may be enormously increased.

Our knowledge concerning the energy requirement for the performance of external work is fully and very ably reviewed and appraised. It is shown that such data as those obtained by Benedict and Cathcart enable us to state with fair accuracy the increase in the demand for energy which goes with a given increase in work. This, however, applies only to work done within comparatively narrow limits. We have, for instance, no satisfactory data bearing on the cost of the more sedentary occupations.

In discussing the protein question the authors seem to be less at home. They do wrong, for example (though the point is perhaps of no great importance), in associating our modern conception of the metabolism of protein, involving, as it does, important chemical, as well as energetic, considerations, with the name of Rubner, who has given attention only to the all-important details of protein nutrition under compulsion born of other people's work. The authors justly pillory in the course of their historical discussion the vice of quotation at second hand; but it is just as bad to over-emphasise quotation from one particular original source unless its authority outweighs all others. On the protein question much more illuminating work and discussion have come from America and this country than from Germany.

*"An Inquiry into the Composition of Dietaries, with Special Reference to the Dietaries of Munition Workers." Medical Research Committee; Special Report Series No. 13.

Selenium as a Decolorizing Agent in Glass

Glasses decolorized by means of selenium are more brilliant than similar glasses decolorized by means of manganese or nickel oxides, but acquire a brownish tinge on prolonged exposure to bright sunlight. The decolorizing action is due to the presence of minute particles of selenium which tend to give a red color to the glass and thus neutralize the faint green coloration due to iron. Selenium is readily oxidized, and hence can be used with advantage only in the absence of oxidizing agents (nitre, etc.); preferably arsenic trioxide is added as a reducing agent. When sodium selenite is used, this is decomposed with liberation of selenium dioxide, and the latter is reduced to selenium either by the arsenic trioxide or by the furnace gases. The coloring effect of 1 kilo. of iron oxide can be neutralized by 0.208 grm. of selenium. For ordinary glass of good quality 0.1 grm. of selenium or 0.2 grm. of sodium selenite may be used for 250 kilos. of glass. The portion of the glass batch containing the selenium should be added to the pot at the second filling on. Glass decolorized by selenium may usually be recognized by its brilliance and by the reddish tinge it acquires on prolonged heating.—*Note in Jour. Soc. Chem. Ind. on a paper by W. Frommel in Kerom. Rund.*

Supplies of Jute from Egypt

Officials in the Sudan region report extensive areas of the true jute (Corchorus olitorius), on the White Nile, occurring in a wild state in the vicinity of swamps and islands. The plant was found growing to a height of 6 feet, and the natives have been retting it for rope making. It is stated that another fiber plant (Hibiscus), was also met with in the same locality under similar conditions. This, too, was being retted by the woodcutters, who obtain from it a fine white fiber of great strength. It is considered that the swamp land of the White Nile affords great facilities for the development of jute and similar fibers. This land is extensive and is not required for other crops. It is naturally irrigated, and the supply of water for retting is unlimited.

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